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494402

Summary Document

Summary of tasks performed on the Shuttle-C/NLS Contract (NAS8-37145) for the period from January 1, 1992 through January 31, 1993 in lieu of Contract DR's as directed by the contract Statement of Work.

January 12, 1993

(NASA-CR-192483) SUMMARY DOCUMENT OF TASKS PERFORMED ON THE SHUTTLE-C/NLS CONTRACT (United Technologies Corp.) 429 p

N93-22995

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Summary Document

Summary of tasks performed on the Shuttle-C/NLS Contract (NAS8-37145) for the period from January 1, 1992 through January 31, 1993 in lieu of Contract DR's as directed by the contract Statement of Work.

January 12, 1993

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1.0 *PROGRAMMATICS*

During FY92, USBI performed many programmatic related tasks. These programmatic tasks have been categorized as follows:

1.1 Acquisition

1.2 Project Engineering/Program Planning

1.3 Cost

The reports associated with these tasks follow in paragraphs 1.1.1 through 1.3.3. Proceeding each task report is a brief description of the contents contained within.

1.1 ACQUISITION

The following is a list of reports associated with USBI's FY92 acquisition related tasks.

1.1.1 Consortia Data

1.1.2 SOW Definition Process

1.1.1 Consortia Data

Task report 1.1.1 is a collection of consortia data gathered to provide information to NLS acquisition planners for use in developing the "best" means to procure the NLS. It contains definitions, examples, types, advantages, and disadvantages of consortia.

- The American Heritage Dictionary defines a consortium as "any association or partnership."

- Consortia are often confused with Joint Ventures
 - Generally, Joint Ventures involve some equity ownership and are limited to three to four members with most involving only two.

 - Consortia involve funding and large numbers of participants, in some instances 100 or more.

- 10 common types of R&D Consortia

- The Two most prominent US research consortia
 - Microelectronics and Computer Technology Corp. (MCC)
 - Semiconductor Manufacturing Technology Initiative (Sematech)

- MCC is totally industry funded

- SEMATECH is half industry funded and half government funded

- The Assessment on how successful the consortia are is mixed.

Types of R&D Consortia

R&D Sponsor Pool-Members pool their funds to sponsor research at universities or other institutions. The pharmaceutical and biomedical industries have been frequent users of this type of consortium.

Basic Research Cooperative-Conducts basic, risky research that would not otherwise be undertaken by the individual members. Most Basic Research Cooperatives must not go beyond development of generic technologies or they may face antitrust exposure.

Equity Joint Venture-One of oldest forms of consortia. Two or more firms share the financing, ownership, risks, returns, losses, and decision making. Founding firms take an equity position in the venture, which allows them to form and operate a new company.
The venture may be formed in perpetuity or it may be created to perform a specific project.

Non-Equity Joint Venture-Firms do not take any equity position nor do they acquire one another. Examples are cross-licensing and cross-marketing agreements, second source vendor or developer agreements.

University Research Center-These Centers are generally seeded by federal monies or by private funds. As Center grows, it becomes self supporting from industrial sponsorship. Sometimes, member firms simply pool their funds and interests to initiate centers at selected universities. Examples are the university centers started by IBM and Control Data Corporation at several universities.

R&D Limited Partnership-Born of recent tax laws. Unique device for amassing long-term financing through public participation. Consists of general partner that initiates the partnership, the RDLP legal structure, the R&D performer(s) and the limited partners. The general partner is a firm that contracts with other firms or research institutes to perform the R&D. RDLP units are sold to public investors, who are the limited partners.

Industry R&D Institute-Second most popular consortium in the U.S. after the Trade/Industry Association. Industry members sponsor R&D for their industry through a central clearing house. Examples are the Electric Power Research Institute and the Gas Research Institute.

Trade/Industry Association-Any non-profit organization of competitors and/or non-competitors formed to expand an industry's outputs, sales or employment, or to provide other benefits. Most common form of collaboration.

Industrial Development Cooperative-Formed by State governments. Example is the North Carolina formed Micro-Electronics Center of North Carolina (MCNC), supported half by state funds and half by industry contributions, consisting of firms and government agencies working together to conduct mission-oriented electronics research that will aid local industry.

Government Agency-Industry Program- Groups of firms working together under the sanitizing structure of some government agency. Programs are usually limited-life, ad-hoc arrangements formed for the sole purpose of making a specific topical study.

Consortia Advantages

Funding for Basic R&D
Funding for Risky R&D
Cost and Risk Spreading
Technological Learning
Environmental Benefits
Threat Buffering
Expanded Information
Standardization
Improved Technology Transfer
Avoidance of Duplication
Facilities Pooling
Byproduct Utilization
Better Intelligience
Technology Acquisition
Management Training

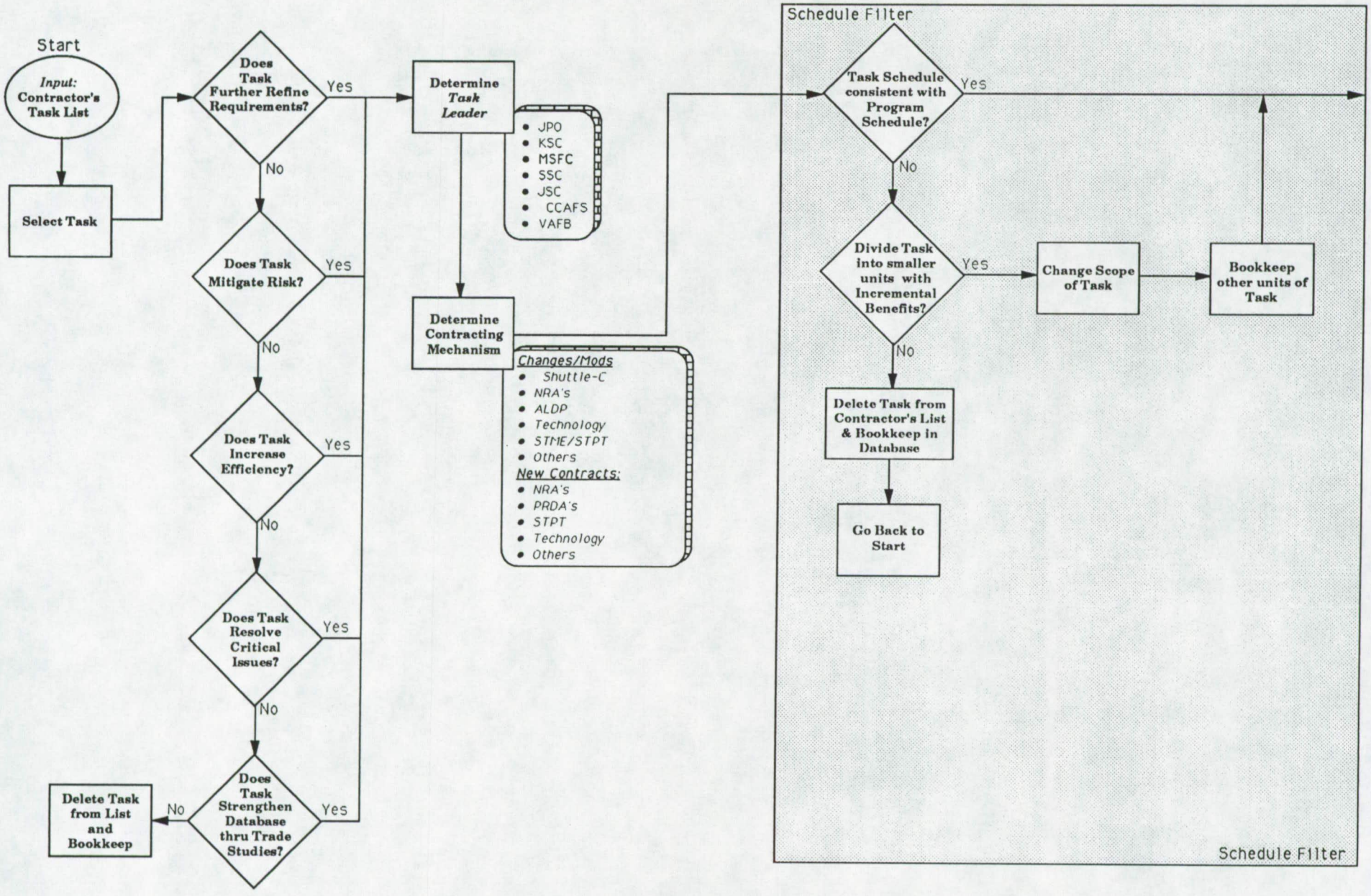
Consortia Disadvantages

Loss of Proprietariness
Loss of Control
Loss of Flexibility
Bureaucracy
Slowness of Response
Cultural Barriers
Equity Problems
Management Problems
Project Selection
Opportunity Costs
Risk of Failure
Sunk Costs
Operating Costs
Staffing Problems
Uncertain Output Value

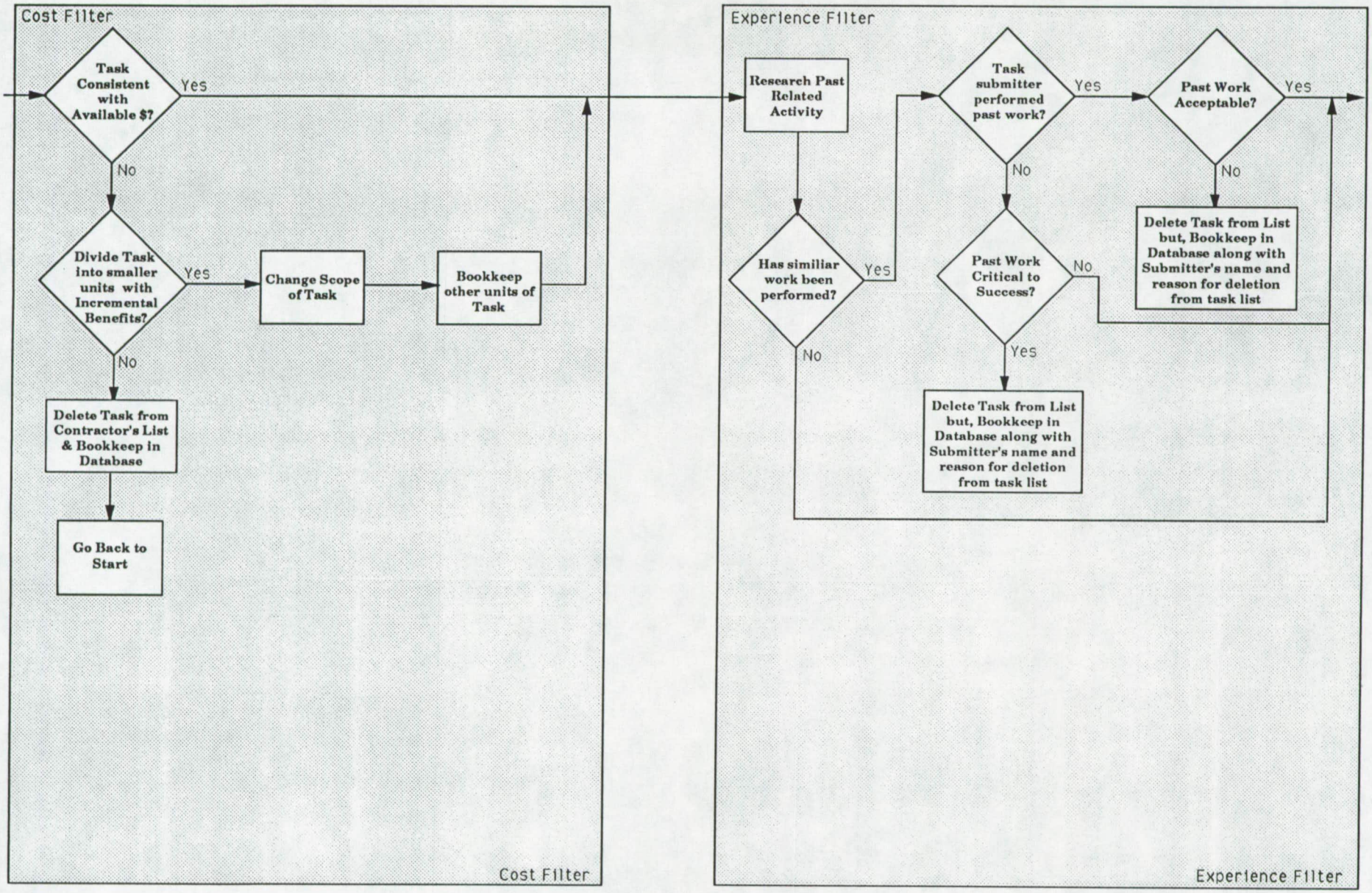
1.1.2 SOW Definition Process

Task report 1.1.2 is SOW Definition Process which is intended to provide a means of evaluating proposed tasks. Input into the process is a list of proposed tasks; each task is driven through a series of screens and filters, and the surviving tasks are suitable for a statement of work.

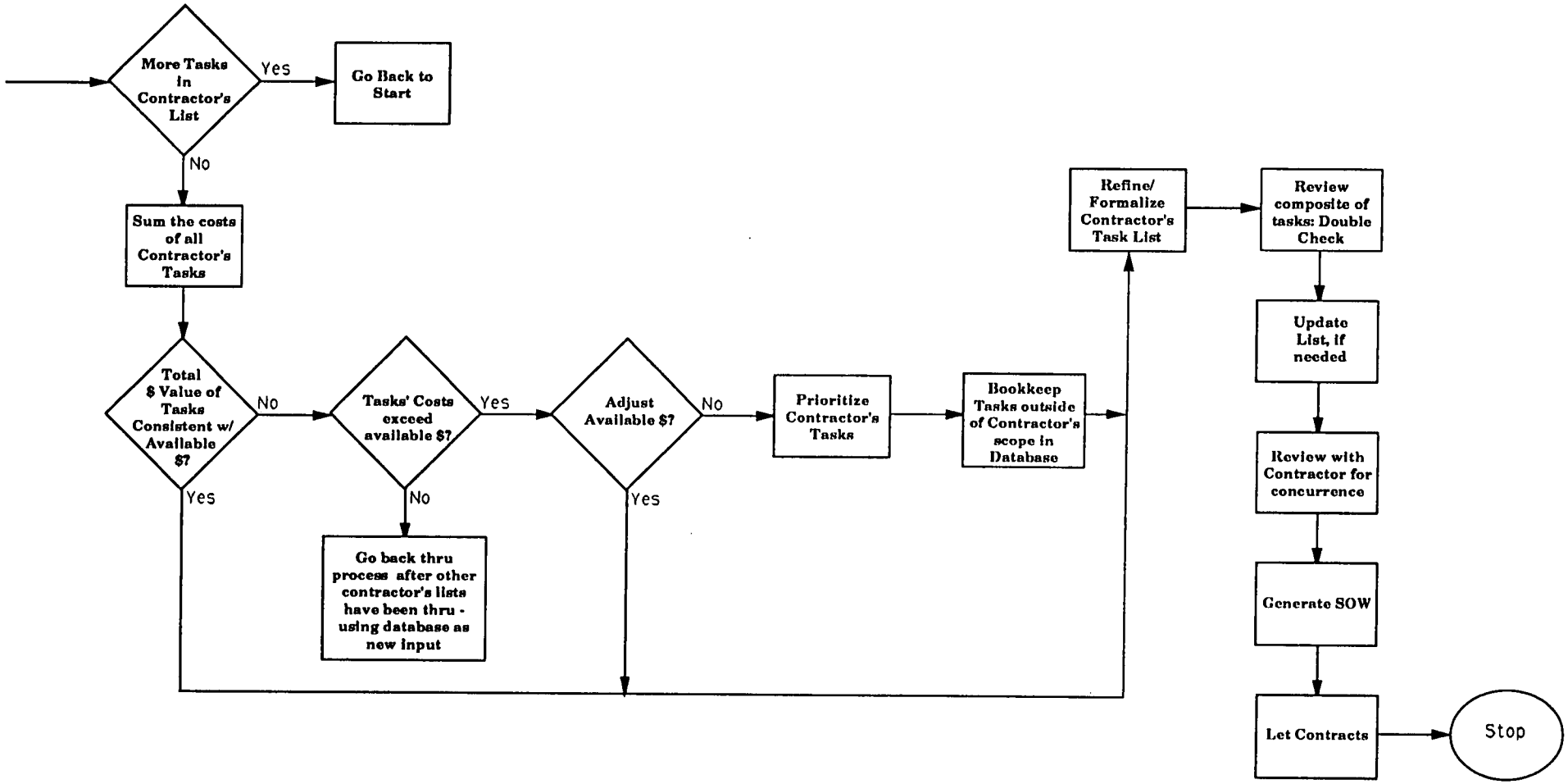
SOW Definition Process



SOW Definition Process



SOW Definition Process



1.2 PROJECT ENGINEERING/PROGRAM PLANNING

USBI's FY92 major emphasis was on project engineering/program planning. Consequently, the majority of the FY92 task reports fall into this category. The following is a list of these reports.

1.2.1 Red Team Review Participation
1.2.2 Program and Contractors' Managers' Review #2 Material
1.2.3 Program and Contractors' Managers' Review #3 Material
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1.2.16 WBS Review and Comments
1.2.17 DR Summary

1.2.1 Red Team Review Participation

USBI, along with other contractors, participated in the Red Team Review. The purpose of this review was to perform an independent technical evaluation of the NLS design reference document and provide an assessment of MSFC management by applying corporate knowledge background to the presented data. Results of this review were included in the MSFC NLS Red Team Review Summary Presentation report which is not attached, but is available upon request.

1.2.2 Program and Contractors' Managers' Review #2 Material

Task report 1.2.1 is the material USBI presented at the second Program and Contractors' Managers' Review held January 15-16, 1992. A list of the topics discussed follows. Items in **bold** represent key areas of emphasis.

- What's important to the program?
- How should the program proceed?
- What are the top priorities?
- What's key other than the vehicle?
- How can we achieve real cost reductions?
- Recommendations
- Preparations for the National Space Policy Directive #4 Decision
- Some key points
- **Phased Program Approaches**
- Characteristics of a sellable NLS Program

NLS Government and Contractors Program Manager's Review

NUMBER TWO

January 15-16, 1992

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NLS Program Review

January 15, 1992

Topics Shopping List

- ✓ What's important to Program?
- ✓ How should program proceed?
- ✓ What are top priorities?
- ✓ What's key other than vehicle?
- ✓ How...achieve believable costs?
- ✓ What can...cause real cost reduction?

 How...improve performance?

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NLS Program Review

January 15, 1992

Review/Analyze National Space Launch Background

- History–series of studies
- Augustine–Stafford Reports
- National Space Council Directives
- Congressional Actions

Postulate/Examine Key Questions

- What were key 1991 NLS actions?
- What external factors are significantly affecting NLS?
- What is overrall environment in which NLS must contend?

Formulate Program Assessments

- Status of NLS program
- NLS requirements/needs
- What key tasks 1992?
- How to achieve real cost reductions?
- Specific Recommendations

Recommendations

2232-1

NLS Program Review

January 15, 1992

What are Key NLS Program Actions to Date?

- President's Space Policy Directive #4, 10 July 91
 - Joint NASA/DoD development of NLS
 - Decisions in FY 1993
- NLS endorsements—Augustine, Stafford, etc.
- NLS "J. R. Thompson/ LG Cromer" defined approach
 - Joint NASA/DoD at $10B–$12B
- Reference vehicle definition–Cycle 0
- Space Transportation Propulsion Team (STPT)

NLS Program Review

January 15, 1992

What 1991–1992 Factors...Affecting NLS?

- Massive federal budget deficits
- Severe domestic economic recession
- Major perturbations to total NASA and DoD programs
- Election year
- Vice President's space policy advisory board
 - Planned independent assessment of NLS February 1992
 - Review options and planning–decisions 1993
- NRC strategic propulsion assessment committee
- Space Exploration Initiative concept formulations
- Organizations
 - MOU continues open
 - NASA organization shifts
 - DoD/Air Force JPO move to BMO
- FY92 budget still open–less than expected

Assessment #1—Status of NLS Program

- NLS program did not *sell* in 1991
 - Decreasing probability of FSD start in 1992 or 1993
- Severe environment for any new start
- Negative fallout from other programs
 - SSF, Titan IV upgrade, B-2, etc.
- Lack of sufficiently strong NLS "user" or proponent
 - SEI
 - SSF
 - STS off-load
 - Titan IV
 - Commercial

Assessment #2—NLS Program Requirements/Needs?

- Requirements must ultimately emerge—can several *soft* requirements be articulated into a *sellable set*?
- President's Space Policy Directive #4—NLS is the center piece—Space haulers for early 21st century
 - Joint NASA/DoD development—focus at Level I is the key
 - Evolutionary/flexible—growth potential to satisfy evolving future needs
 - Cost effectiveness/operability

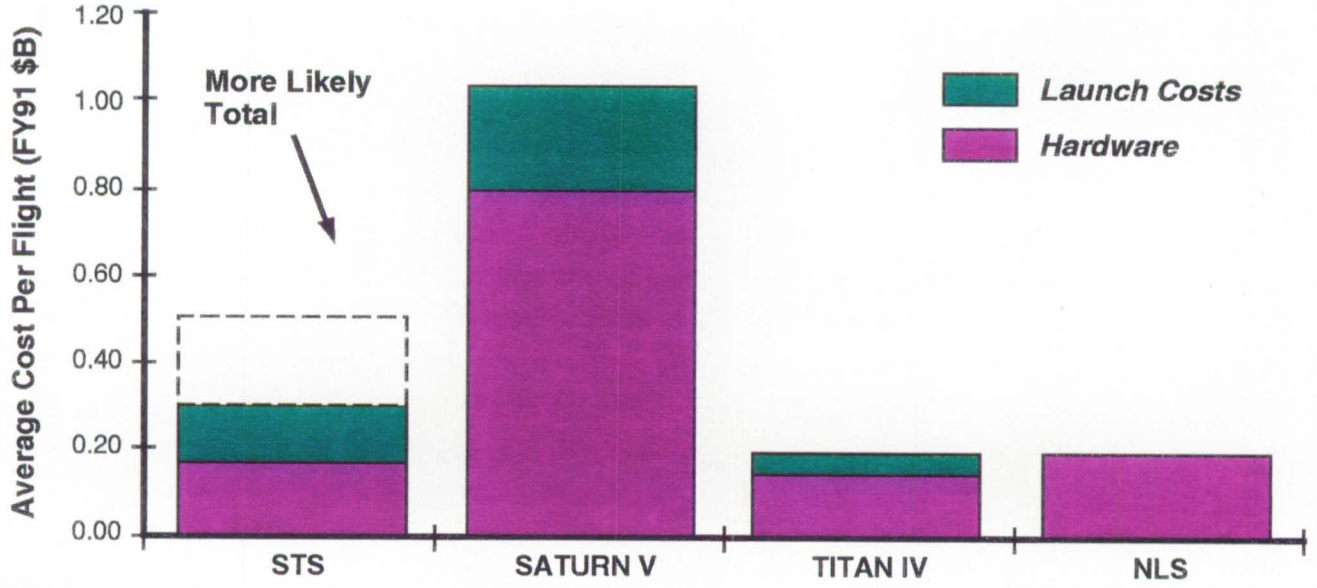
Assessment #3—What are Key 1992 NLS Program Tasks?

- Plan NASA/DoD joint program approaches—(Consolidated Level I)
 - Congressional coordination is key
- Prepare alternatives and options for NSC program decisions in FY 1993—respond to Space Policy Directive #4
- Clearly identify the growth to support SEI options
- Complete definition of baseline program vehicle and concepts

Assessment #4—How Can We Achieve Real Cost Reductions?

Operations Cost

- Our assessment of the MSFC NLS operations costs indicate:
 - Costs are lower than NASA history would suggest
 - Achievable with aggressive cost containment
 - 40% reduction already taken must be defined/implemented
 - Costs are slightly higher (13%) than Titan IV
 There is a significant difference in the two vehicles
 - Costs are about half of actual STS costs



Assessment #4—How Can We Achieve Real Cost Reductions?

Operations Cost (Contd)

- To reduce operations costs, the following candidates have been identified:
 - Two separate launch sites
 - Man-rateable
 - Simpler design concept
 - Engine out
 - New ways of doing business:
 - Ship and shoot
 - Reusable hardware
 - Factory of the future
 - Standardized payloads
 - Standardized payload operations
 - Automated checkout/launch
 - Technology advancements

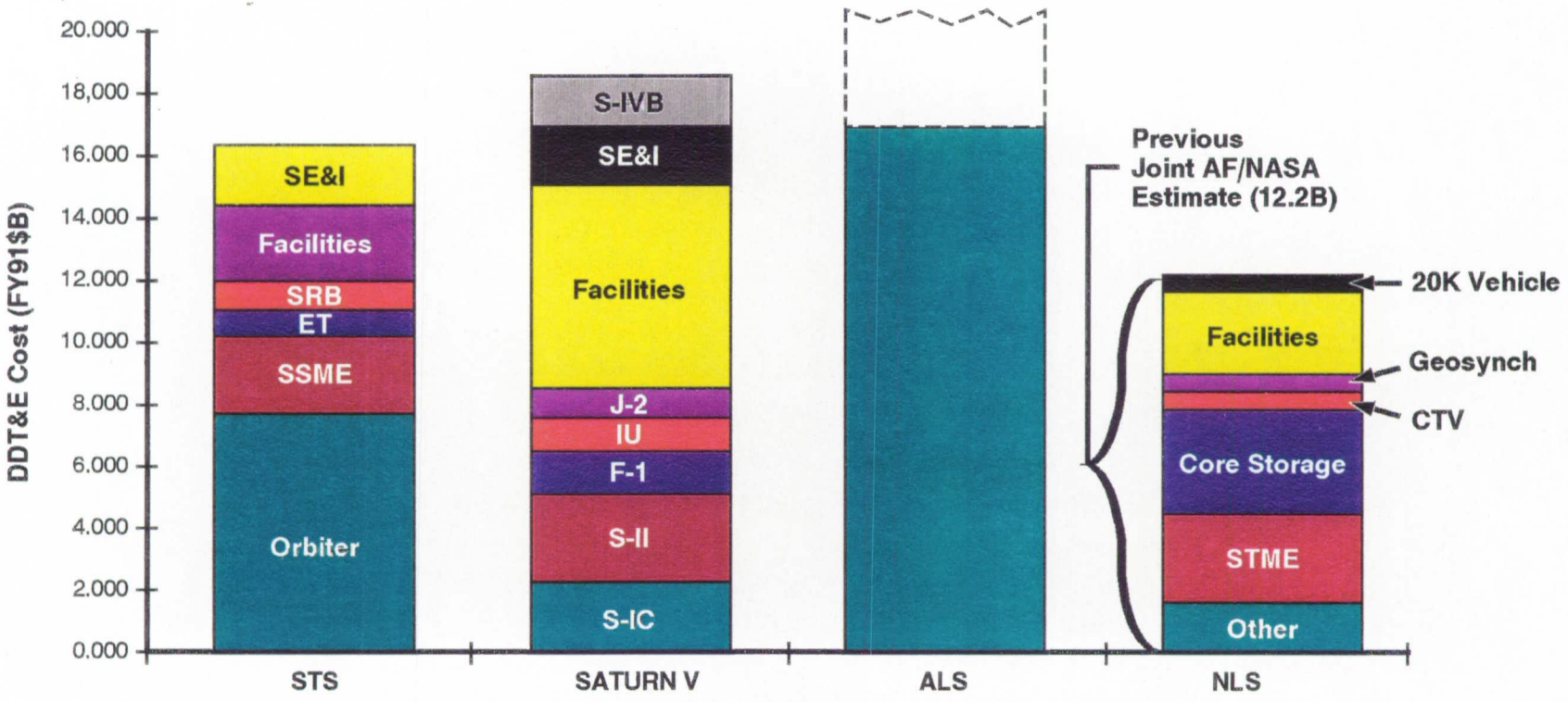
- Operations improvements may increase DDT&E cost

NLS Program Review

January 15, 1992

Assessment #4—How Can We Achieve Real Cost Reductions?

DDT&E Cost



Launch vehicles of NLS class cost about $17B for DDT&E. Are costs of $12B too high?

Assessment #4—How Can We Achieve Real Cost Reductions?

- $/pound to low earth orbit and costs per launch are only two measures
 - Cost of launch delays, scrubs, inordinate payload integration timelines and catastrophic failures more difficult to express
 - Value of robustness, operability, flexibility and efficiency difficult to express in $/pound

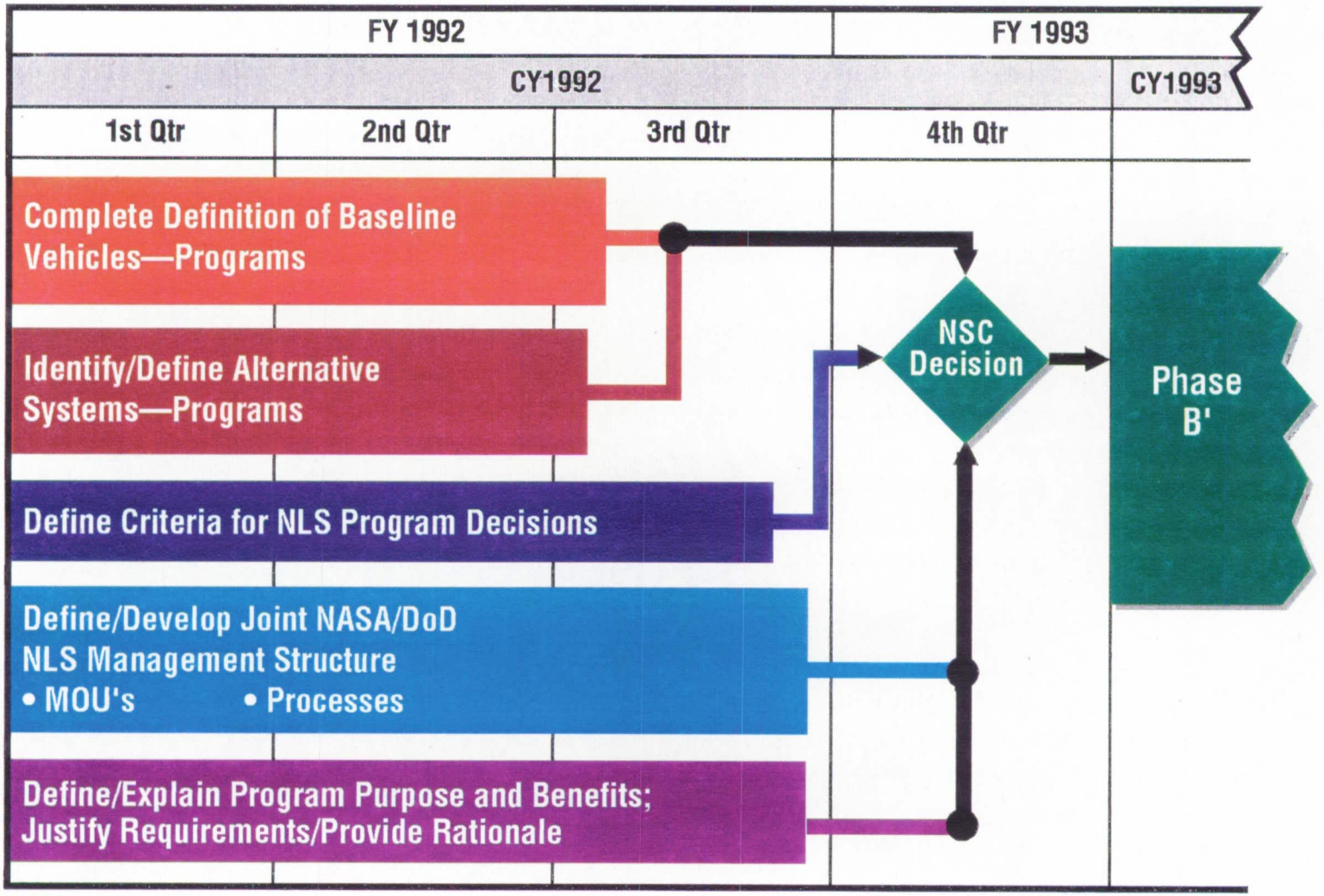
Recommendations

- Requirements must ultimately emerge
- DoD/AF and NASA interests must be focused for program approval
- Joint Program Plan and acquisition process must be clearly defined
- Plan and criteria should be established to support the Vice President and National Space Council decision in 1993
- Input for FY93 NSC decision should be prepared

NLS Program Review

January 15, 1992

Preparations for National Space Policy Directive #4 Decisions



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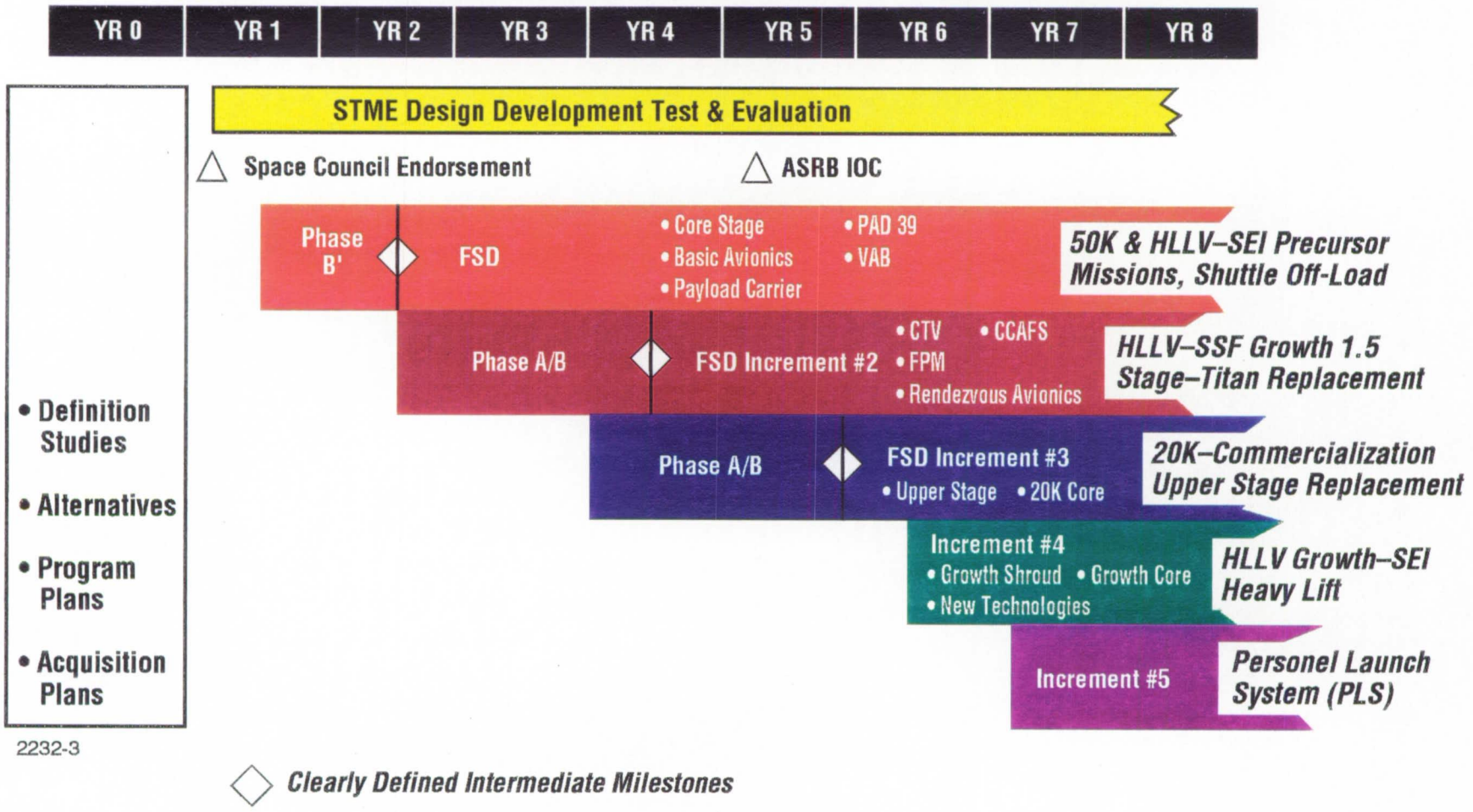
Some Key Points

- Launch Vehicles not built in vacuum
 - Exists to *launch* something
 - Requirement to launch justifies vehicle
 - Saturn V built to put man on moon—Apollo
- NLS justification dependent on SEI, SSF, STS off-load, Titan IV replacement, other users
- "Urgency-Criticality" of STS off-load, SEI, etc. has not been established.
- Appears *urgency* may not be quickly established
 - Incremental process/phased program

NLS Program Review

January 15, 1992

Phased Program—Example

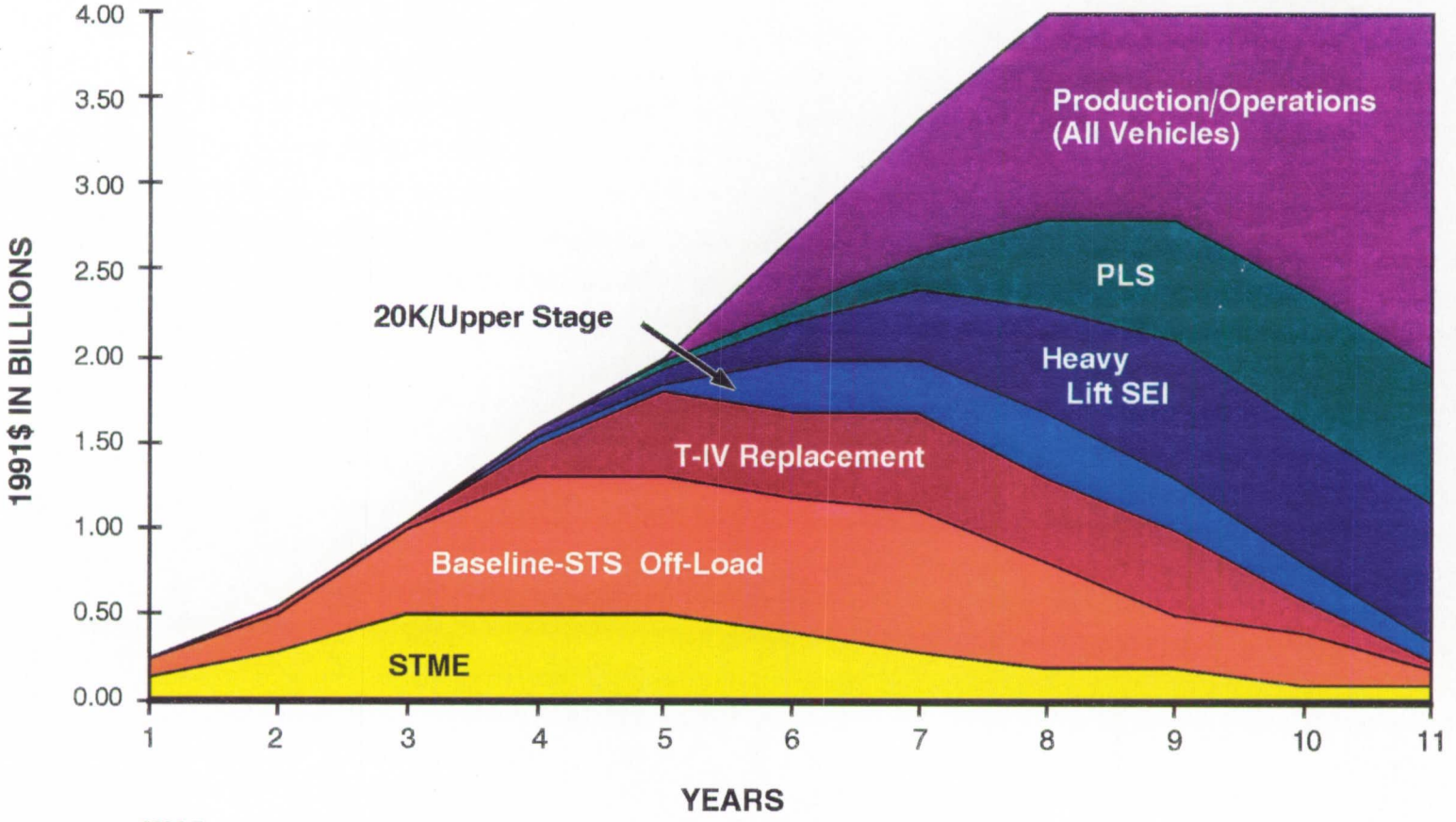


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◇ *Clearly Defined Intermediate Milestones*

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Phased Program Example Costs



2232-7

Characteristics of Sellable NLS Program

- Justified on 21st Century "Mans Future in Universe", "Space Exploration"
- Supported by sound—"Back-to-basics Program Plan"
- Step by step approach to "Family of Launch vehicles" and "assured access to space"
- Logic trail to show path to satisfaction of user requirements
 - Space Exploration Initiation
 - Space Station support
 - Military space launch requirements
 - Commercially competitive
 - Reliability, cost effectiveness
- Series of milestones, individual procurements and incremental decision points over 15 years.
- Hard ties to: STS off load, SSF support, SEI and Titan IV replacement

1.2.3 Program and Contractors' Managers' Review #3 Material

Task report 1.2.2 is the material USBI presented at the third Program and Contractors' Managers' Review held March 19-20, 1992. A list of the topics discussed follows. Items in **bold** represent key areas of emphasis.

- Suggestions for Quarterly Review
- **Opportunities for Change**
- Current View of the NLS Program Prospects and Plans

NOTE:

USBI also led the coordination of this review, which involved the logistics of the review and establishing an appropriate agenda.

National Launch System
Program Manager's Review

March 19-20, 1992

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Program Manager's Review

March 20, 1992

Agenda

- ✓ Suggestions for NLS Quarterly Review
- ✓ Opportunities for Change
- ✓ Current View of the NLS Program Prospects and Plans

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Program Manager's Review

March 20, 1992

Quarterly Review

- NLS Program would benefit from the initiation of a Quarterly Review with the Center Director.

- Quarterly Review format should follow the standard project quarterly review format, i.e.;

 - Emphasize on problem areas warranting attention of Center Director
 - Presentations by project elements (WBS elements)
 - Presentations should address
 - Plans for the quarter
 - Accomplishments
 - Plans for next quarter
 - Action items from previous quarterly reviews.

- Major portion of the agenda/presentations should be Government personnel since the Phase B is an in-house led effort.

- Contractor presentations should be limited to special topics (as opposed to all contractors presenting at all quarterly reviews).

Program Manager's Review

March 20, 1992

Agenda

- ✓ Suggestions for NLS Quarterly Review
- ✓ Opportunities for Change
- ✓ Current View of the NLS Program Prospects and Plans

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Opportunity for Change—Introduction

- Initial, 20 February response to Lowell Zoller, categorized cost drivers into three areas: management, developmental, operational
 - Consider "design-to-cost" and "operate-to-cost" philosophies (new culture–TQM) to control program cost
- Subsequent efforts looked deeper
 - Focus on requirements stability, identification and resolution of "loose cannons"
 - Identification of various NLS "customer voices"
 - Vigorously search for/question conflicting voices
 - Attempt to trade/measure priority among customers
 - TQM principle focus on the customer needs

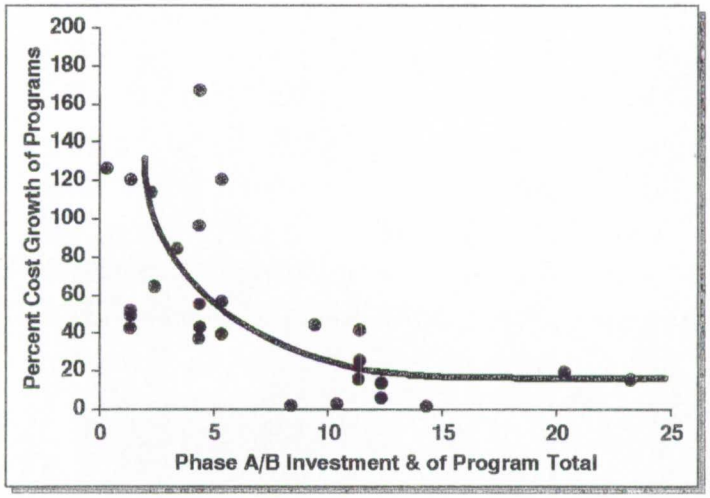
Changes

- Change of NASA/DoD space launch cultures is "integral" to the NLS approach:
 - Joint NASA/DoD development and use of launch vehicles (Reduced overhead)
 - Replace multiple mission systems (Titan, Atlas, Delta, offload Space Shuttle) with *one* family (Less overall logistics, sustaining engineering, etc...)
 - Joint NASA/DoD use of launch facilities (commonality)
 - No manned launch vehicles for simple cargo launch requirements (simplicity)
 - Evolvable systems (accommodate future growth)
 - Cost and operability major program focus (not just vehicle performance)

Ill-Defined Requirements

Importance of Good Program Definition

- Incomplete Phase A/B technical definition causes cost growth. Leads to:
 - Requirements Understatement
 - Incomplete or Inaccurate Cost and Schedule Estimate
 - Program Turmoil, Redirection, Growth and Downscoping
- Investment in dollars and effort in Phase A/B has tremendous pay-off in cost growth



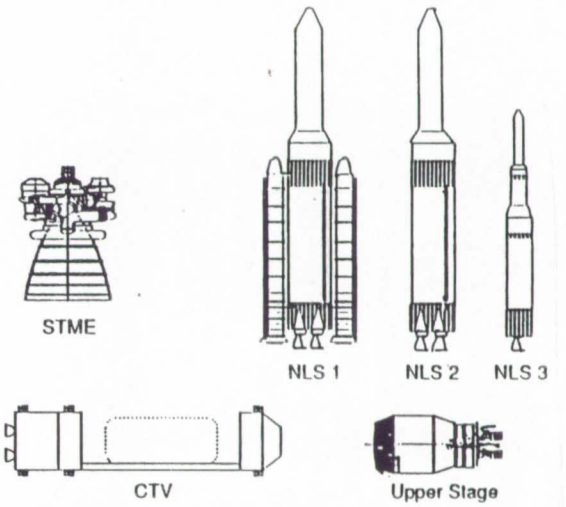
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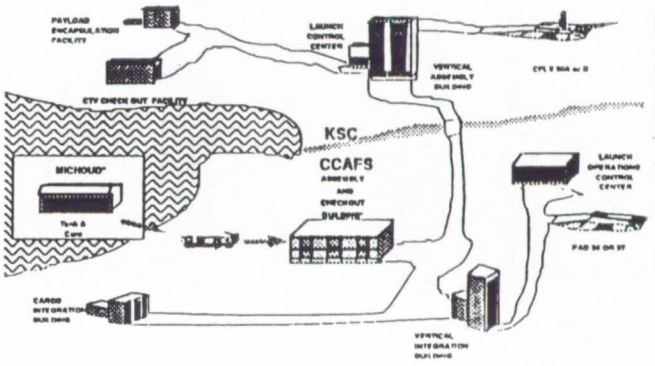
NLS Susceptibility to Incongruences

- Scope and breath of program
- Multitude of customers
- Joint NASA/DoD–differing cultures and focus
- Ties to other changeable programs – commercial, DoD-Titan, STS, SSF, SEI
- Evolving requirements and priorities
 - Commercially competitive with Ariane
 - 20K (NLS#3) vehicle priority
 - De-emphasis of space based SDI
- Changing government organizations, budgets and emphasis

NLS Program Content

- Space transportation main engine (STME)
- Three launch vehicles
 - NLS 1 (135K)
 - NLS 2 (50K)
 - NLS 3 (20K)
- Cargo transfer vehicle (CTV)
- Upper stage
- Facilities
 - Manufacturing
 - Kennedy Space Center
 - Cape Canaveral Air Force Station

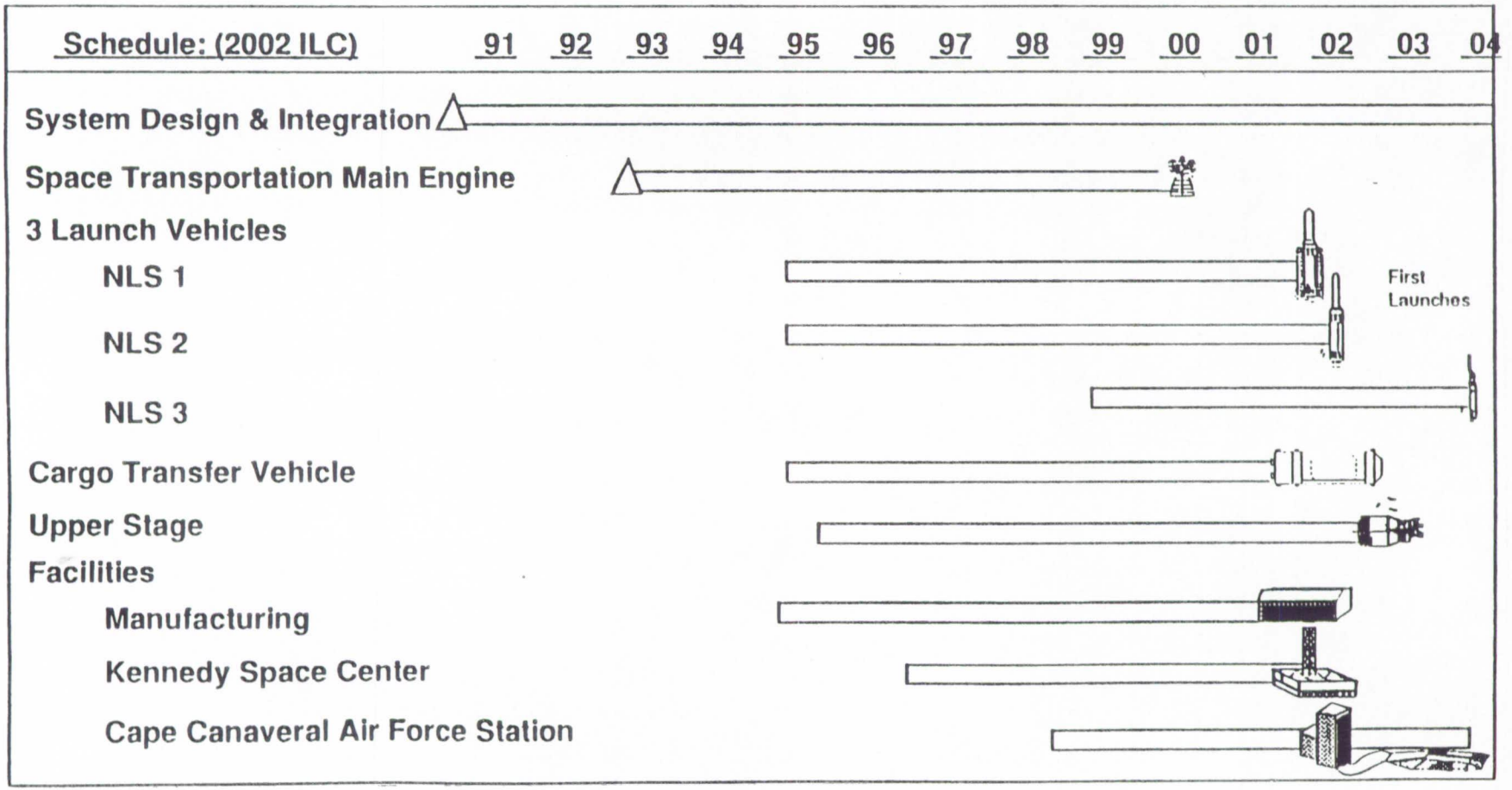




Program Manager's Review

March 20, 1992

NLS Development Schedule



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Cost Control Methodology

Cost is not free standing—it reflects the inherent elements comprising the program (i.e., requirements, groundrules, and technical content). If the costs exceed desired limits then these elements must be reduced or changed.

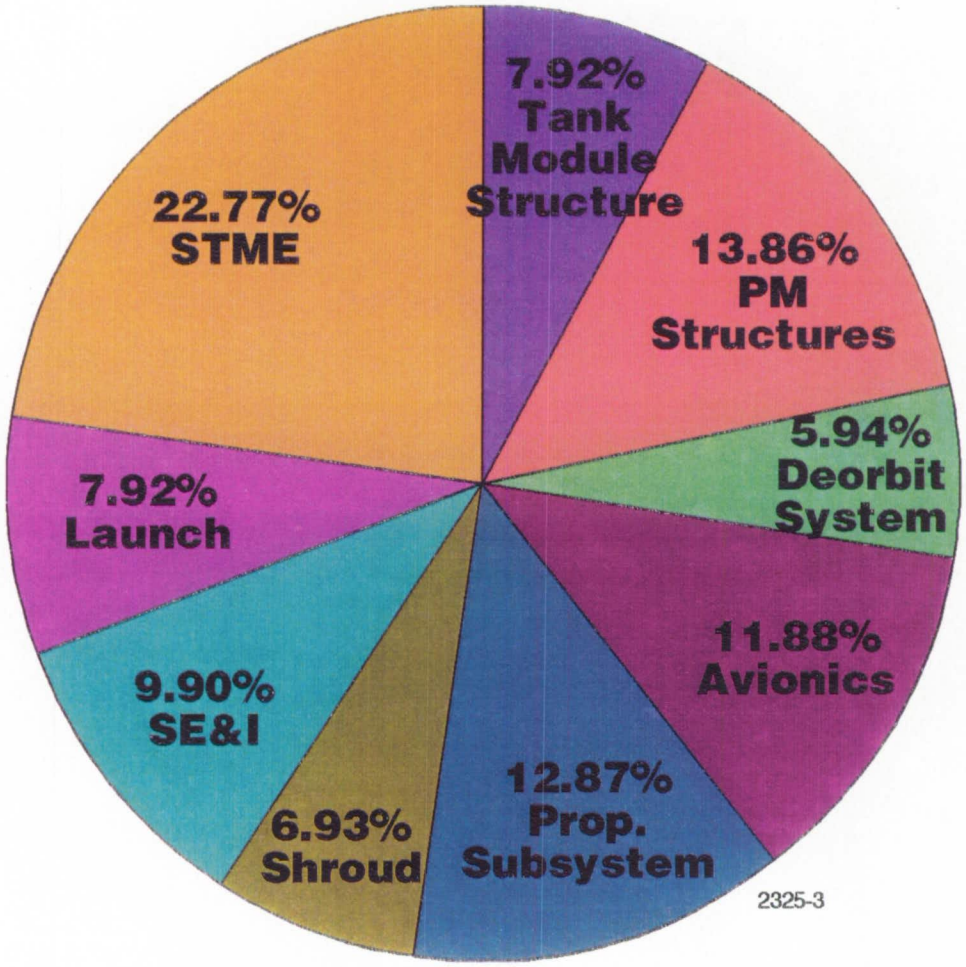
- **Unstable Requirements Drive Cost (loose cannons)**

- **Technical Requirements Drive Cost**
 - **Man-Rateable**
 - **No On-Pad Access**
 - **SSF Rendezvous**
 - **Engine-Out**

- **Management Decisions Drive Cost**
 - **Joint Program**
 - **DSS**
 - **Two Launch Sites**
 - **Acquisition Strategy**

- **Culture Drives Cost**
 - **success-at-all-costs**
 - **STS Heritage**
 - **SRM&QA**
 - **Documentation**

Cost-Per-Flight Breakdown



Technical Requirements

Cost Drivers

- Man-Ratable
- Engine-Out
- Cargo Transfer Vehicle
- Natural Environment Protection
- Cryogenic Fluids
- No Pad Access
- Concurrent STS Operations
- System Security
- Payload Assignment Changes
- Reliability/Dependability
- Growth Capability
- STME
- STS Compatibility
- Surge
- Resiliency
- Dependability
- Support Costs
- New Launch Facilities

Example of Cost Dilemma

For NLS cost per flight to equal Titan IV's, the requirements must be somewhat equal. This is not currently the case. For example, a comparison of NLS and Titan IV indicates:

	Avionics Comparison		
	NLS	Titan IV	Comment
Redundancy	Quad Single String	Single String	
Vehicle Design Reliability of .98	0.993 (avionics allocated)		Current single string thought to be near .95
Vehicle Launch Dependability of .90 (within 10 days)	0.967 (avionics allocated)	N/A	
PAD Access	No	Yes	
Complexity (2 fault tolerant)	Man-Rateable	Unmanned	
Derived Mission Life (Avionics Pre-launch through deorbit)	338 Hours		Near 20 hours
Weight	3800 lbs		
Average unit cost	≈ $18M	≤ $5M	

Note: NLS unit avionics cost already reduced by 38% for *new ways of doing business* savings.

Technical Requirements

No On-Pad Access

- Maintenance Planning (paragraph 3.12.2) and integrate-transfer-launch (paragraph 5.1.4) have been interpreted to mean no on-pad access to launch vehicle.

- Implementation of this requirements drives:
 - Processing loaded payloads through the VAB—safety consideration—increases operational requirements and costs
 - A fourth avionics string to meet reliability and dependability requirements (no change out of failed units)—increases avionics cost
 - Requirement to roll-back if payload failure

- Evolution to transport of humans will require pad access

- Recommend revisit cost/benefit trade to determine cost effectiveness

Technical Requirements

Man-Ratable

- Current guidelines:
 - Manned factors of safety as per MSFC-HDBK-505A
 - Two fault tolerant
 - Verification/demonstration testing to prove reliability
 - Emergency detection system
 - Trajectory shaping to accommodate crew (escape system, "g" limit)
- Significant cost driver to the unmanned vehicle—requires the manned and unmanned vehicles to be the same except for systems that are specifically crew related.
- If existing STS manned requirements are imposed on NLS, even greater cost impacts will occur:
 - Class S EEE parts for avionics system
 - Software in the redundant avionics strings must be developed by separate developers

Technical Requirements

Cryogenic Fluids

- Level II SRD, Para. 3.2.2: "The NLS will provide accommodations for loading and unloading cryogenic and other fluids within payloads..."
- Safety ramifications
 - Processing loaded payloads through the VAB
 - Increases operational requirements, costs
- May require payload on-pad access—counter to integrate-transfer-launch philosophy

Technical Requirements

Natural Environment Protection

- Level II SRD, Para. 3.1.5: "Capable of withstanding adverse weather, and direct lightning strikes...This capability will be provided...while on or in transit to/from the launch pad, or in flight."
- Provides robust vehicle with capability for launch on demand
- All-weather capability
- Requires on-board lightning protection both during ground transit and inflight
- Thermal protection system and external structures must be capable of withstanding adverse weather

Management Requirements

Cost Drivers

- Joint Program
- Level I/II/III
- Chain of Command
- Decision Support System (DSS)
- Two Launch Sites

Culture Factors

Cost Drivers

- Potential conflict among BMO, AF/SD, NASA cultures
- STS heritage
- Success-at-all-costs approach
- Documentation requirements
- SRM&QA over reliance on testing
- Sequential Engineering
- Government duplication and oversight

Cultural Caution

- Virtually every program partially based upon groundrules and assumptions involving cultural changes
- Program cost estimates sold on the cost savings to be gained by the cultural changes
- Too often the cultural changes are not achieved and the project is thrown immediately into a cost problem
- Examples of changes that are often factored into early planning that do not materialize:
 - Design to cost
 - Freezing cost at system/subsystem level
 - Hardware breadboarding
 - Minimum contractor oversight by government
 - Reduced documentation

Program Manager's Review

March 20, 1992

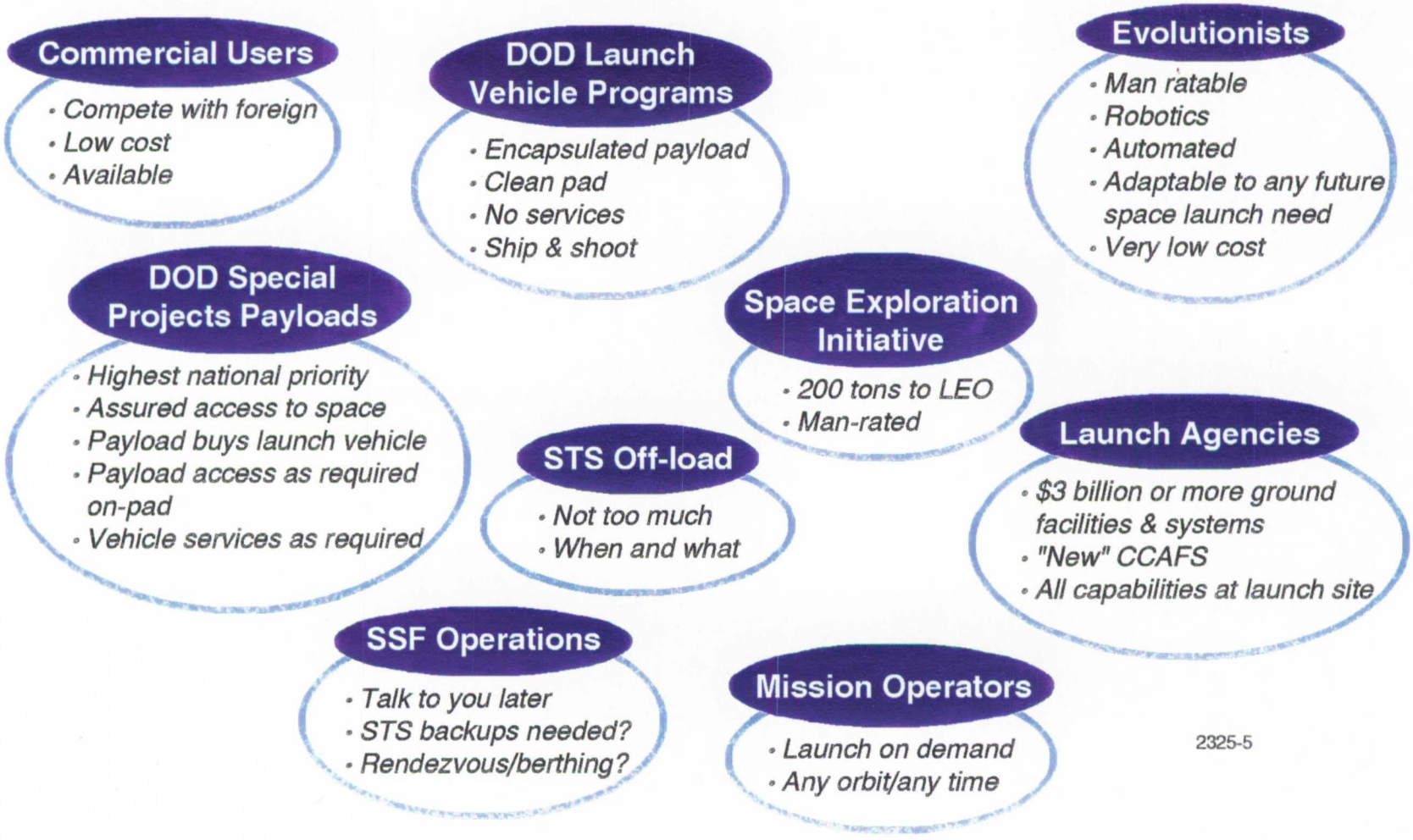
Agenda

- ✓ Suggestions for NLS Quarterly Review
- ✓ Opportunities for Change
- ✓ Current View of the NLS Program Prospects and Plans

Program Manager's Review

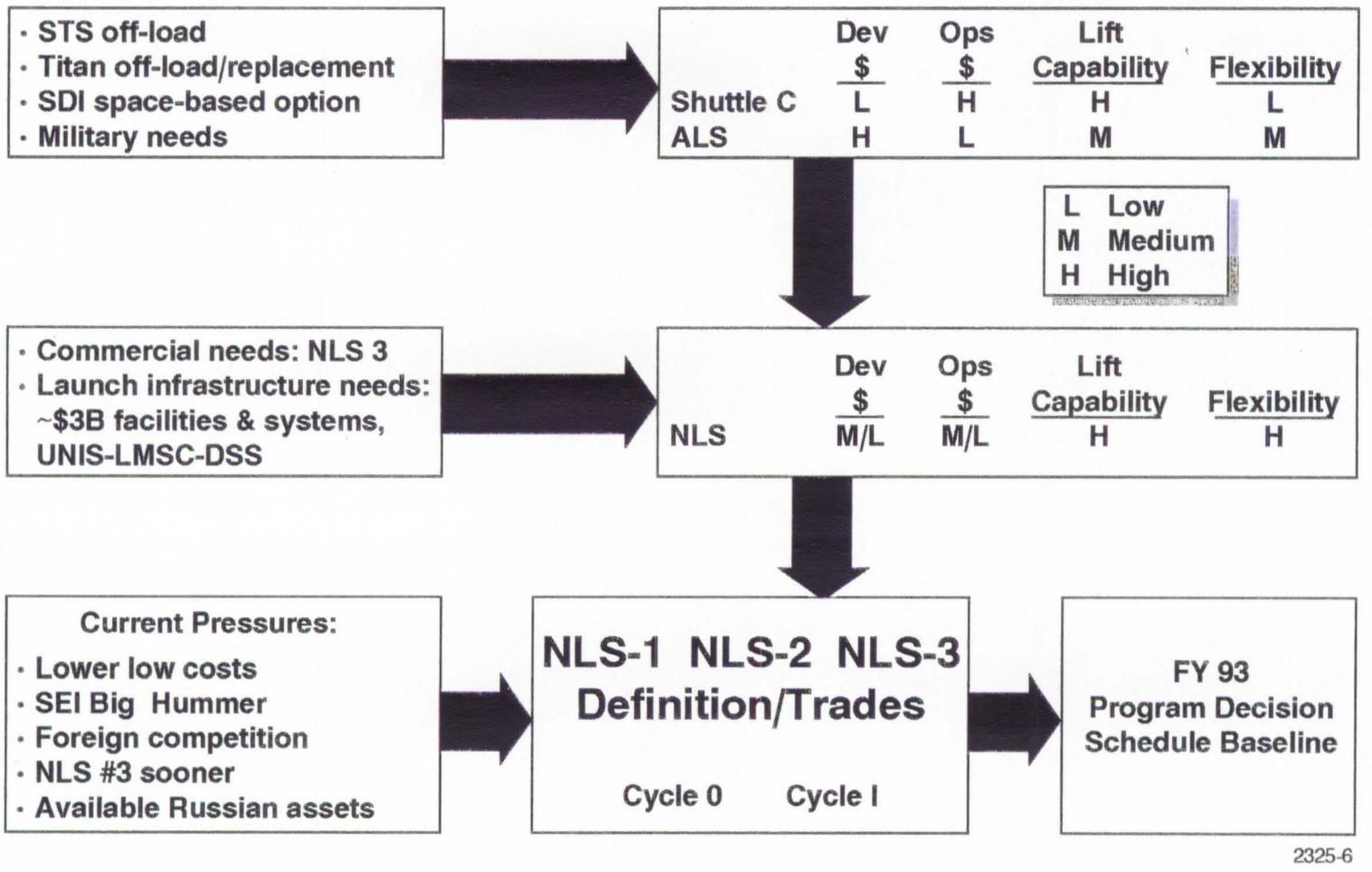
March 20, 1992

Identifying and Classifying the NLS Customer Voices



2325-5

Simplified Flow NLS Compromise Solutions (Definition Phase)



2325-6

Program Manager's Review

March 20, 1992

Program Status—Elements Status



2325-7

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Summary

- "Opportunity for change" integral to NLS—pushing establishment in all areas

- Extremely challenging—dynamic requirements environment and definition phase
 - Complex program
 - Many customers (requirements tend to conflict)
 - Relative customer priority may be variable
 - Enabling requirement still elusive (no consensus)

- Cycle 0 effort—successful—good reference for trades and alternatives
 - Most "loose cannons" can now be identified
 - Additional Phase B essential to "secure cannons"
 - Question/attack requirement incompatibilities
 - Trade study/analyze issues and alternatives
 - Develop system engineering and integration
 - Define program interfaces and management structures

Summary (Contd)

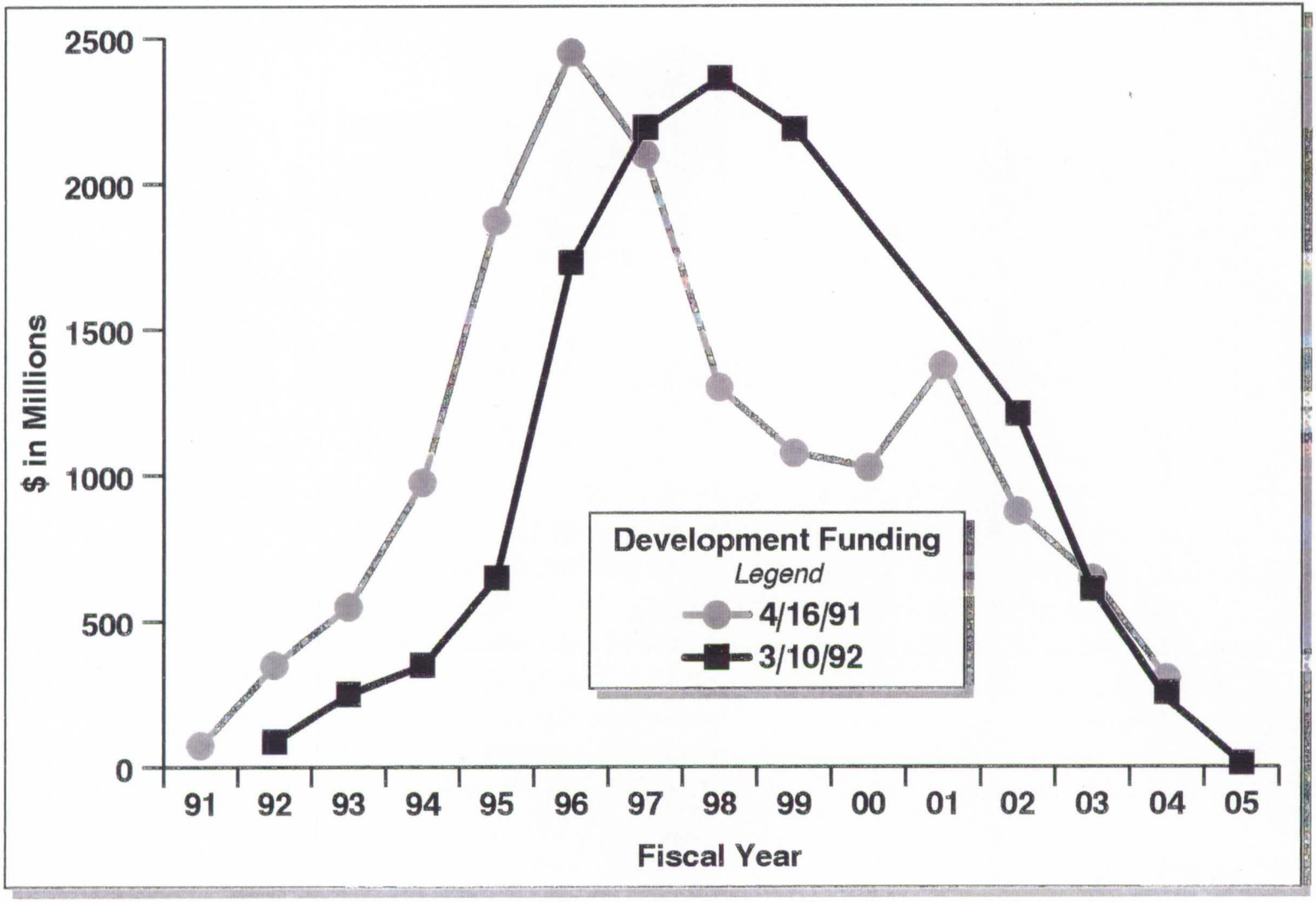
- August 1992 "DAB like" review
 - FY 93 NSC review/decision—alternative schedules
 - Air Force Level III entities (Space Division, BMO, ESMC)
 - NLS #1/NLS#2 trades
 - NLS #3 priority and schedule trades
 - Acquisition planning
 - Program NASA/DoD optimized
 - Cost/requirement creep containment system
 - Interface control
 - Program management systems
 - Evolutionary pathways

Technical Requirements

SSF Rendezvous

- Implementation of this requirement drives the need for a CTV.
- SSF delivery requirements uncertain
 - Initial Assembly: NLS/CTV not available
 - Logistics: Currently Under Evaluation. Current plan based on reusable carrier and high down-mass; requires STS or recoverable payload carrier
 - Growth: Currently under evaluation
- Current SEI scenarios under evaluation. Is a larger "CTV-Type" vehicle potentially required for orbital assembly?
- Number of CTV flights and flight schedule will influence concept design and recoverable versus expendable trades.

Development Funding



2325-3

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Technical Requirements

Growth Capability

- Consists of:
 - Vehicle hooks and scars
 - Additional facilities
 - Additional analytical databases
- Provides evolutionary path to support SEI

1.2.4 Program and Contractors' Managers' Review #4 Material

Task report 1.2.3 is the material USBI presented at the fourth Program and Contractors' Managers' Review held May 13-14, 1992. A list of the topics discussed follows.

- Program Issues
 - Sponsor/Advocacy
 - Enabling Requirements
 - Initial Development (20K/Commercial)
 - Budget Pressure/Keeping Contractor Teams Together
- Commercialization
- Current View of the NLS Program Prospects and Plans

MSFC/NLS
Program & Contractors
Manager's Review

May 13-14, 1992



NLS Review

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Agenda

- Issues
- Commercialization

NLS Review

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Issues

- **Sponsor/Advocacy**
- **Enabling Requirements**
 - **Competition/Cost Effective**
 - **Replace/Supplement Aging Fleet**
- **Initial Development (20K/Commercial)**
- **Budget Pressures/Keeping Contractor Teams Together**

NLS Review

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Sponsor/Advocacy

Strong Sponsorship

- White House Support:
 - President's Speech — July 20, 1989
 - Augustine Report — December, 1990
 - President's Directive #4 — July 10, 1991
 - National Space Council

 However,

 NLS banner must be carried in the Washington Arena

- NASA Support:
 - NLS is in the budget
 - NLS *supports* Goldin's Four Legged Stool Philosophy
 - Human Presence
 - Mission to Planet Earth
 - Exploration (Robotics & Manned)
 - Leader in Aeronautics

- However, what is its priority?
 - All NASA Programs under review

NLS must fit into the overburdened NASA menu

NLS Review

Sponsor/Advocacy (Contd)

- **DoD Support**

 - **In the budget (response to Presidential Directives)**

 However,

 - **Not the NLS flag carrier**
 - **Titan, Atlas, and Delta are direct competitors**
 - **Availability is a concern**

- **Congressional Support**

 - **Past space support relatively good**

 However,

 - **Fierce competition for funds**
 - **No long term plan for Congress to support**

Sponsor/Advocacy (Contd)

"Program" Appeal

Appeal	*Solution*
Sputnik	Redstone
"Race to the Moon"	Apollo
Routine Missions	Space Shuttle
Permanent Presence	Space Station
	National Launch System

- USSR Collapse
- Evolving World Competition

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Enabling Requirements

- Cost Effective Access to Space
- Competitive Space Leader
- Upgrade/Replace Aging Fleets
- Off-load STS
- Future Missions - Evolution
- Technology (Development & Spin-offs)
- Education Enhancement - Pull America Forward

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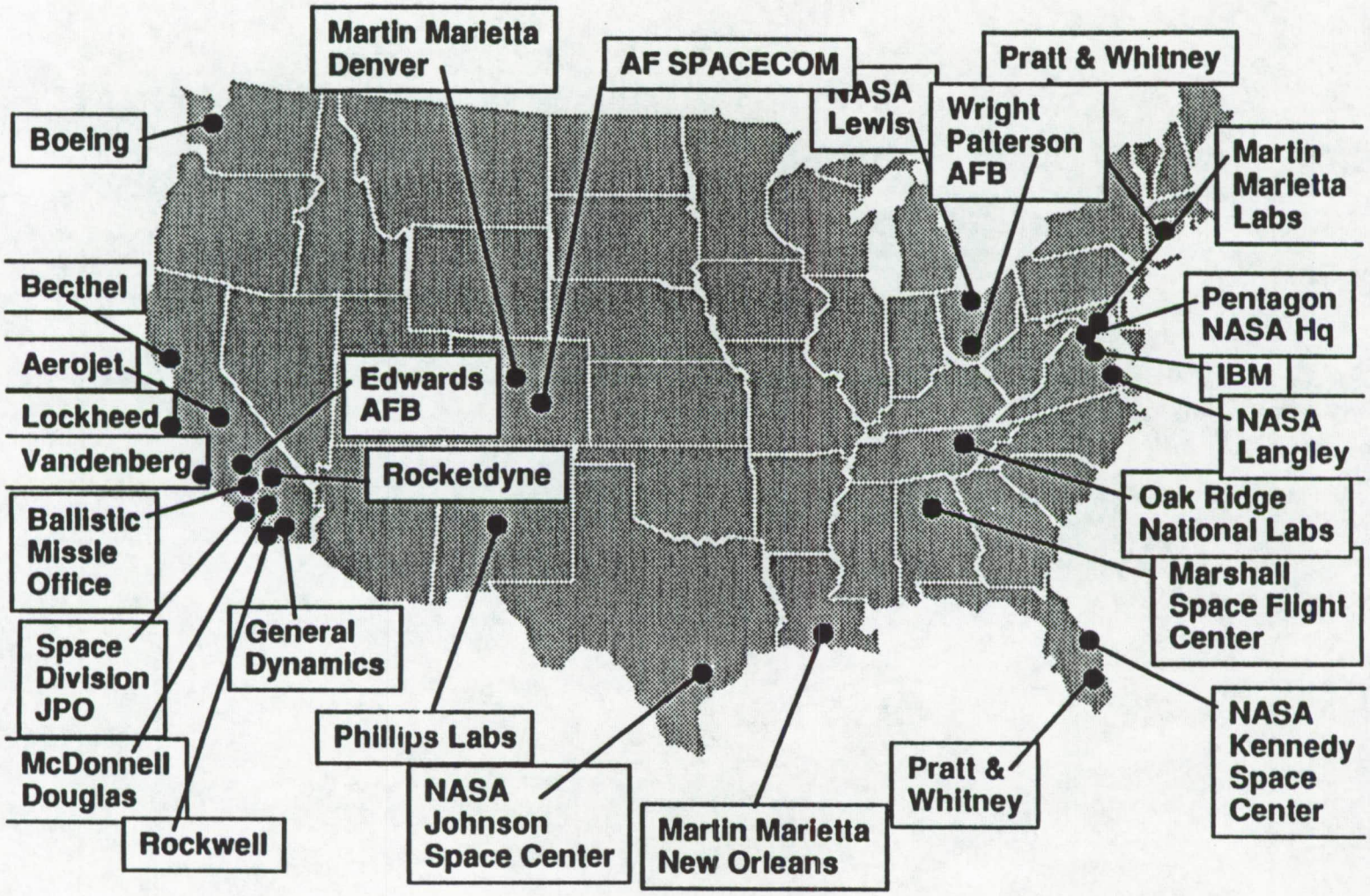
Initial Development (20K/Commercial)

- Focus Requirements
- Costs
- Responsibility
- Near-term areas of emphasis

NLS Review

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Keeping Teams Together



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Recommended Near-Term Plan

- Continue Joint Program
 - Valid intent
 - Get NASA's and AF's intent defined and committed
 - Both Agencies focus NLS—work with Space Council and Congress
- Communicate and reach a consensus with Congress
 - Establish consensus of objectives and support by all parties
- Layout objectives/visions for next several years - short term/long term
- Take plan to Space Council and Congress with content, decision milestones, and funding identified
- Create and communicate an environment so that the Nation can understand and embrace the NLS family plan

Commercialization/NLS

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Initial Development (20K/Commercial)

- Focus Requirements
- Costs
- Responsibility
- Near-term areas of emphasis

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Commercialization/20K Vehicle Thoughts

- Objective – Routine Space Access
 - Available
 - Competitive
- Current Systems/Fleet
 - Aging Technologies
 - Wearing Out – Limited Return On Improvements
 - Costly
 - Manned
- International Competition
 - Strong & Gaining Strength
 - Broadening Field
- Commercial/20K – Why 20K First
 - Build Momentum Against World Competition Threat
 - Launcher Business
 - Satellite Business

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Commercialization/20K Vehicle

- NLS Development Offers Foundation Blocks to Meet the Challenge
 - Early Technology & Module Developments
 - Integrate into Existing Fleet (Atlas, Titan, Delta, STS, etc.)
 - Available for Near Term & Out-Year NLS Family Members

- Development and Operational Costs – "High" When Bookkept Against 20K

 - Saturn V/Saturn IB Precedence
 - Space Station – Precedence Common Module
 - 20K First Implies
 - Bookkeeping of Common & Unique Costs
 - First User Learning Curve

Commercialization/20K Vehicle

- An Option– Establish a Common Core for Technology/Development
 - Expand Engineering Development/Demonstration and ADP Activities
 - Design & Develop Key Items and/or Modules
 - Power Plants, Engines, Avionics, Reaction Controls, Actuator Systems, Shrouds, Pads, etc.
 - Process Items to "Ready for Production" Status
 - Distribute Jobs to Several Contractors?
 - Costs Are Allocated to a "Common Core" – Not To a Specific Vehicle
 - Outputs Available
 - Upgrade Existing Fleets
 - Any NLS Family Member
- Methods/Plans to Develop and Transition the 20K to Industry Must Be Evolved Early-On

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Initial Development (Contd)

NLS Infrastructure

Family Technologies Development
Modules Development

NLS Review

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Keeping Teams Together

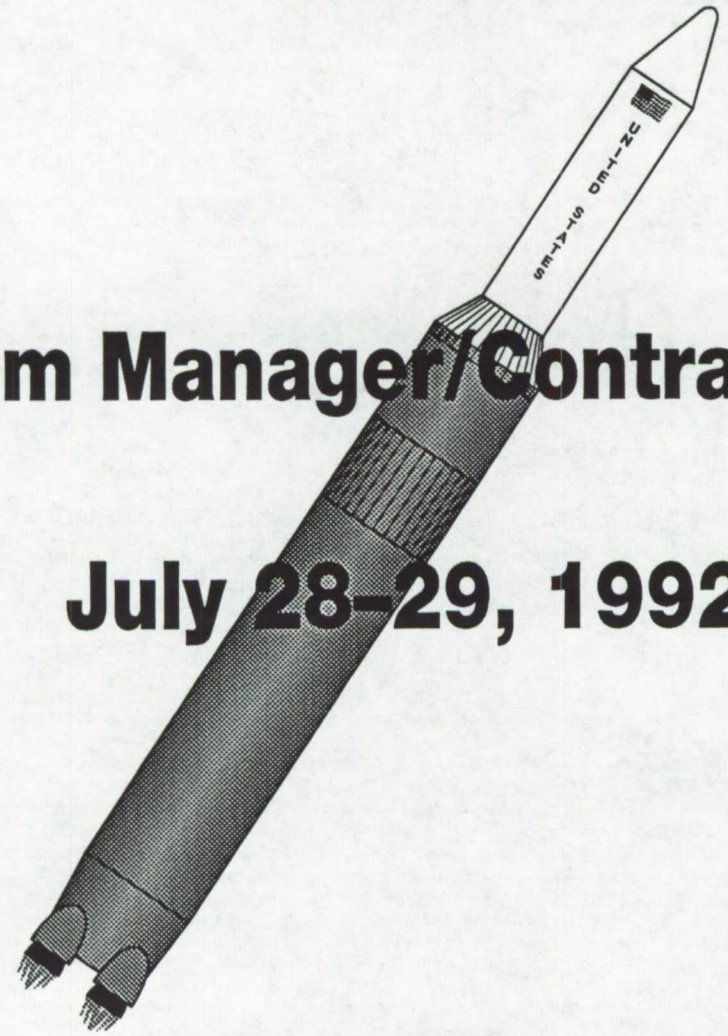
- **Program Continuity**
- **Support definition activities**
- **Utilizes corporate knowledge/background**
 - **Continues team atmosphere**

1.2.5 Program and Contractors' Managers' Review #5 Material

Task report 1.2.4 is the material USBI presented at the fifth Program and Contractors' Managers' Review held July 28-29, 1992. A list of the topics discussed follows. Items in **bold** represent key areas of emphasis.

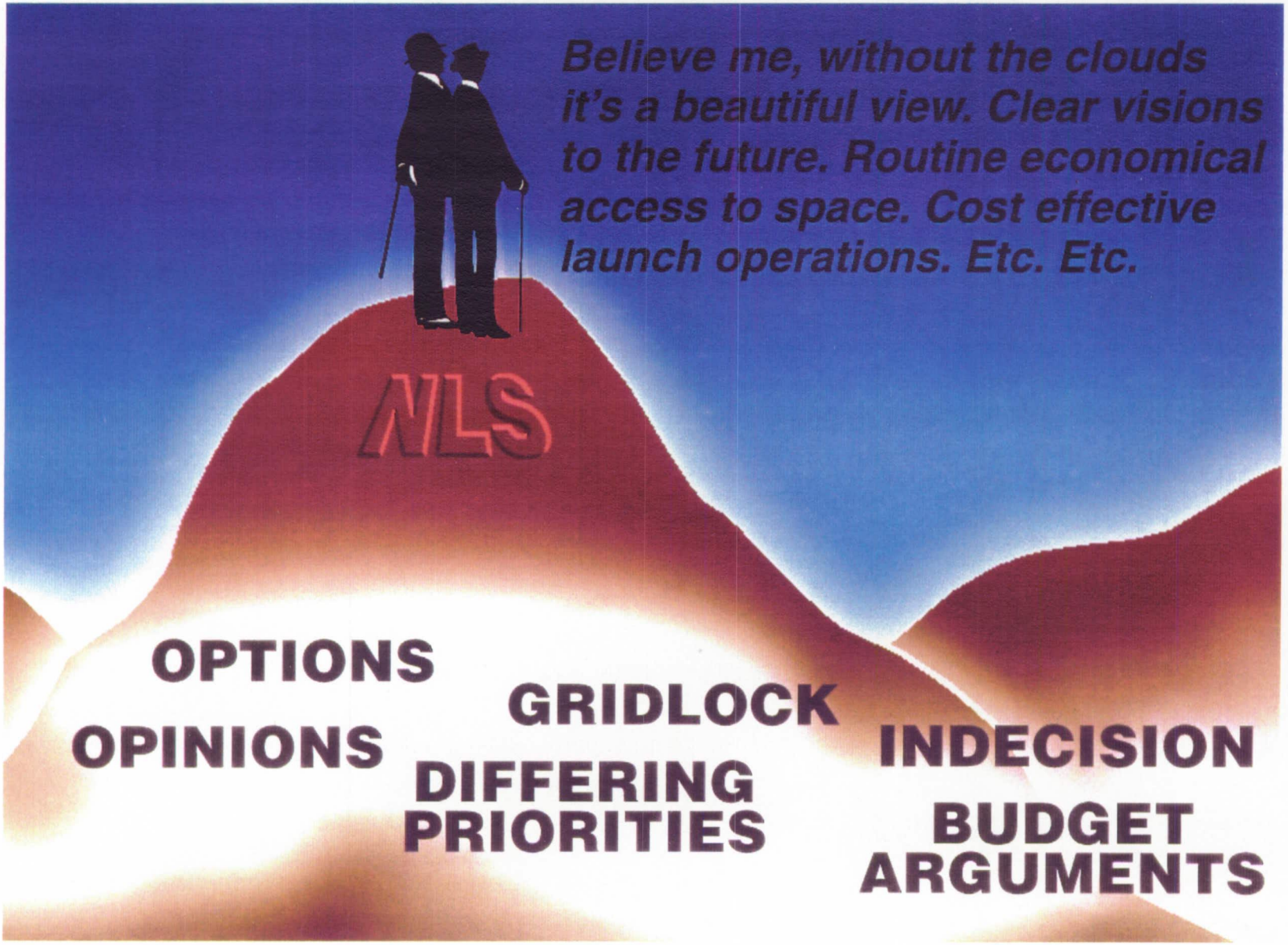
- NLS Pictorials
- NLS Full-Scale Development
- Summary of the National Space Council Memorandum (July 1, 1992)
- US Space and Defense Sectors Closely Related
- **Importance of Good Program Definition**
- **Implementing New Ways of Doing Business**
- **Limitations of New Ways of Doing Business**
- DOD and NASA Program Acquisition Planning
- Engine Out

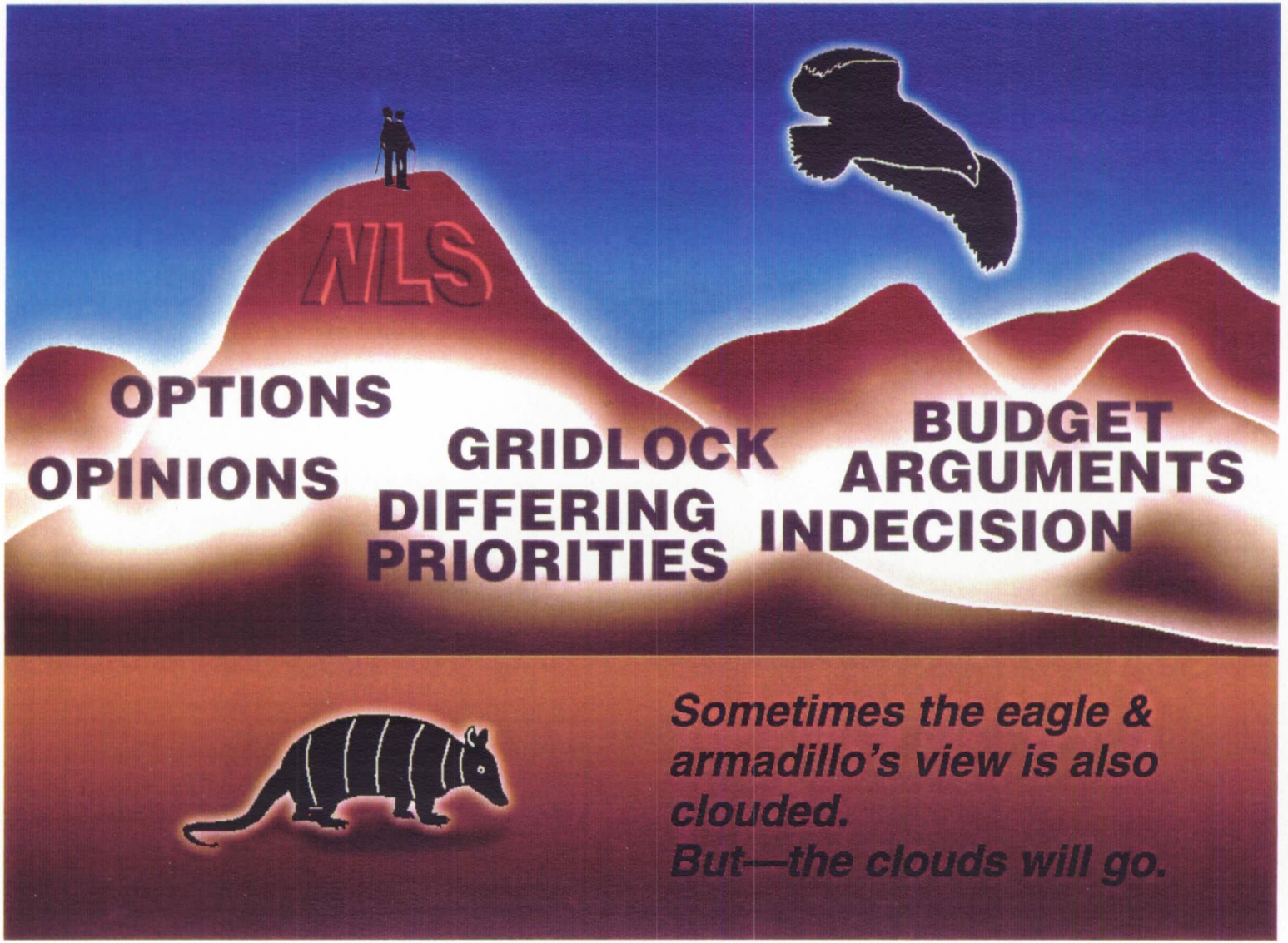
NLS Program Manager/Contractors Review



July 28-29, 1992

UNITED TECHNOLOGIES
USBI


Believe me, without the clouds it's a beautiful view. Clear visions to the future. Routine economical access to space. Cost effective launch operations. Etc. Etc.
NLS
OPTIONS
OPINIONS
GRIDLOCK
DIFFERING PRIORITIES
INDECISION
BUDGET ARGUMENTS


NLS
OPTIONS
OPINIONS
GRIDLOCK
DIFFERING
PRIORITIES
BUDGET
ARGUMENTS
INDECISION
Sometimes the eagle &
armadillo's view is also
clouded.
But—the clouds will go.

Decisions Needed

- **Division of Responsibility—NASA/AF (Escpecially Level II and III)**
- **Degree of "jointness"**
- **Type and number of contracts**
- **All "eggs in one basket"—NLS is the only space launch game in town**
- **Program architecture**
 - **Rationale—replace obsolescent expendables**
 - **Evolutionary growth, etc.**
- **Cost philosophy**
- **Implement "new ways of doing business"**
- **International implications**
- **Phasing with STS, space station, SEI, current expendables**

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

National Space Council Memorandum

Subject: Space Policy Advisory Board Activities

July 1, 1992

Launch Strategy Implementation Review

Review the implementation of the President's National Space Policy, Directive #4.

Issues:

- *Actions taken to assure current **systems and infrastructure** remain capable of meeting U.S. space launch need into early years of next decade.*
- *Progress on the development of **NLS**; Can reduction in launch cost (50%) and increase in reliability and responsiveness be attained?*
- *Plans for transition of current **unmanned payloads** to NLS and plans for purchase of **large and medium LV's** to use in 2000 timeframe.*
- *Planned investments in aerospace transportation **technology**.*
 - *NASP*
 - *Single Stage Rocket Technology Program*
 - *Personnel Launch System*
 - *High Speed Civil Transport*
- *Plans for use of excess **ballistic missiles** for space launch.*
- *Activities considering **commercial** space launch needs.*

Provide by November, 1992

2511-3

Provide recommendations to streamline development, reduce cost, or otherwise strengthen the implementation of the Administration's policy objectives.

Applicable NLS Team Products

- **ALDP—Technology**
- **Plans and options**
- **NLS—DEM/VAL Phase Technology Demonstrations**
- **Architectures**
- **Commercial needs**

Specific Actions

- **Define "joint" NASA/DOD**
- **Red/Blue team activity**
- **NLS/SEI tie**
- **Development phasing**
- **Procure "by the yard"**

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

National Space Council Memorandum
Subject: Space Policy Advisory Board Activities
July 1, 1992

Industrial Base Review
(Acquiescence to Space Policy Directive #4)

Assess the current strength of U.S. space related industrial base and prospects for its health and vitality over the next decade.

Factors:

- *Declining Defense Spending.*
- *National Security Needs.*
- *International Competition.*
- *Trade Relationship between U.S. Gov't. &:*
 - *Private Sector, and*
 - *Republics of the former Soviet Union.*
- *China, Japan, and members of the ESA.*

Issues:

- *Effects of **Defense Budget Reductions** including:*
 - *Job losses and potential for loss of critical skills.*
 - *Industrial capacity loss and it's implications for maintenance of a domestic competitive base.*
 - *Loss of an indigenous capability in Industry Sectors and potential reliance on foreign sources.*
 - *Sustaining the cutting edge technology base*
- *Benefits to national security of maintaining a robust **commercial space industry** sector.*
- ***Expanded trade** enabled by end of cold war.*
- ***Impediments** to expanded trade.*
- *Maintaining **U.S. aerospace industry** leadership and worldwide competitiveness.*

Provide by October 1, 1992 2511-4

Advise specific actions, if any, to be taken to strengthen the U.S. space related industry as a whole.

Applicable NLS Team Efforts

- **New ways of doing business**
 - **Faster, more direct**
- **Streamline acquisition process**
- **Stability of requirements**

Specific Actions

- **Break out of study mode**
- **Break grid lock**
- **Start FSD—STME/20K vehicle**

NLS Program Manager/Contractors Review

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U.S. Space and Defense Sectors Closely Related

Number of Program Types in Production*

Sector	1992	1997	Post-FYDP
Airframes	25	16	6
Guns/Cannons	5	2	0
Hulls	9	2	1
Heavy Vehicles	0	0	0
Strategic Missiles (launch vehicles)	7	5	2 → NLS?
Tactical Missiles	20	13	8

Strategic National Strategy Seems Essential

* Source—"Tomorrow's Defense from Today's Industrial Base: Finding the Right Resource Strategy for a New Era"

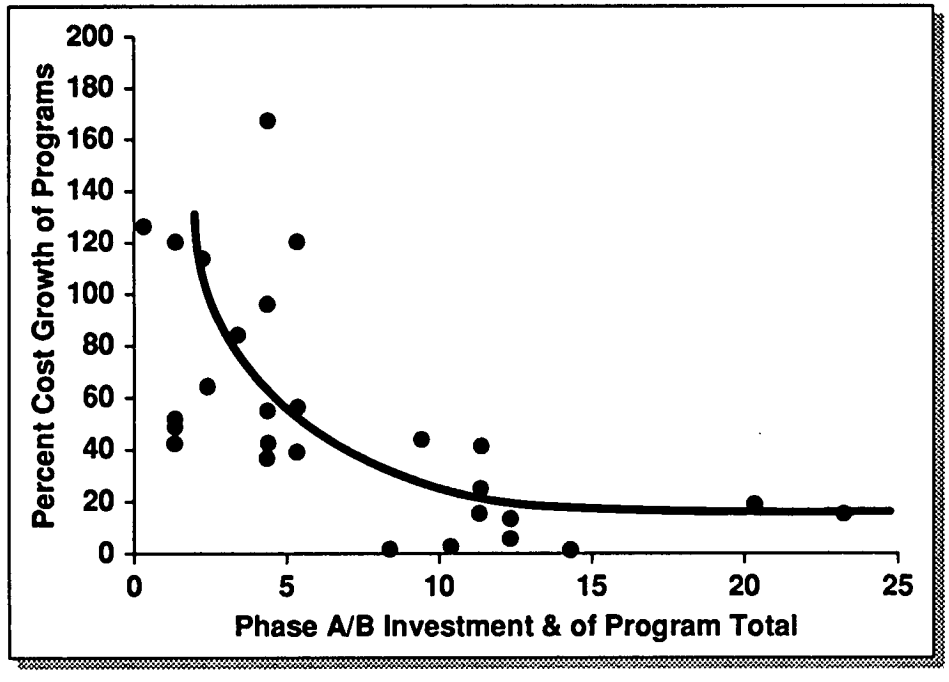
Representative Les Aspin, February 12, 1992

NLS Program Manager/Contractors Review

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Importance of Good Program Definition

- **Incomplete Phase A/B technical definition causes growth which leads to:**
 - **Requirements understatement**
 - **Incomplete or inaccurate cost and schedule estimate**
 - **Program turmoil, redirection, growth, and downscoping**
- **Investment in dollars and effort in Phase A/B has tremendous payoff in cost growth**



2476-43

NLS Program Manager/Contractors Review

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Implementing New Ways of Doing Business

- Procurement and contract management reformed
- Increased safety margins, reduced testing implementation requirements
- Advanced production methods
- Advanced Quality Management
- Streamlined management
- Relaxed materials and parts specification
- Intensified development prior to Phase C/D
- Reduced Government reporting requirements
- Stabilized multiyear funding

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Procurement and Contract Management Reformed

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Streamlined Acquisition Process			M	M		M	S/I		R		✓	✓		
Eliminate Best & Final Proposals			M	M		M	S/I		R		✓	✓		
Solicit Phase C/D Proposal in ØB		S	S	M		M	S/I		R	✓	✓	✓		
Incentivize Cost Control/Penalize Overruns			M	M		M	S/I		R		✓	✓	✓	
More Realistic Contractor Bids			M	M		M	S/I		R		✓	✓	✓	
Consider Fixed Price Contracts				M		M	S/I			✓	✓	✓	✓	

S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-9

C-2

NLS Program Manager/Contractors Review

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Increased Safety Margins, Reduced Testing Implementation Requirements

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Increase Analysis (Instead of Testing)			M	M	M	S/I			R	✓	✓	✓	✓	
More Robust Vehicle			M	M		S/I			R	✓	✓	✓	✓	
Heavier Vehicle • *Reduce Payload or* • *Increased Recurring Cost*			M	M	M	S/I			R	✓	✓	✓	✓	
Reduce/Eliminate System Testing • *Acoustic* • *Structural* • *Dynamic* • *Thermal* • *MVGVT*			M	M	M	S/I			R	✓	✓	✓	✓	
Reduce / Eliminate System Test Hardware			M	M	M	S/I			R	✓	✓	✓	✓	

S = Significant Role
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2511-11

NLS Program Manager/Contractors Review

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Advanced Production Methods

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Materials Requirements Planning (MRP)						S/I			R		✓	✓	✓	
Just in Time Inventory (JIT)						S/I			R		✓	✓	✓	
Bar Coding						S/I			R		✓	✓	✓	
Continuous Flow *• Establish Process Controlled Approach in Lieu of On-Floor Inspection*						S/I			R		✓	✓	✓	
Eliminate Duplicate Test & Checkout Procedures						S/I			R		✓	✓	✓	
Statistical Process Control (SPC)						S/I			R		✓	✓	✓	
Paperless Manufacturing						S/I			R		✓	✓	✓	
Automatic Handling & Inspections						S/I			R		✓	✓	✓	
Robotics						S/I			R		✓	✓	✓	
Net Casting, Laser Drilling						S/I			R		✓	✓	✓	
Advanced Ultrasonic Testing						S/I			R		✓	✓	✓	
Real Time Inspection						S/I			R		✓	✓	✓	
Waterjet Cutting						S/I			R		✓	✓	✓	
Chemical Machining Process						S/I			R		✓	✓	✓	
Super Plastic Forming						S/I			R		✓	✓	✓	
Quick Change Tooling						S/I			R		✓	✓	✓	
Automated Spray Techniques						S/I			R		✓	✓	✓	
Parallel Processing						S/I			R		✓	✓	✓	

S = Significant Role
M = Minor Role
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R = Respond

2511-15

NLS Program Manager/Contractors Review

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Advanced Quality Management

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Continous Improvement/Total Quality Management				M		S/I			R		✓	✓	✓	
Taguchi Method						S/I			R		✓	✓	✓	
Trained Personnel and Certified Processes to Achieve Quality						S/I			R			✓	✓	
Concurrent Engineering/Process Engineering/Design - Build Teams						S/I			R		✓	✓	✓	
Design to Cost						S/I			R		✓	✓	✓	
Customer & Contractor Work Closely on Prod. Dev. Teams						S/I R			R		✓	✓	✓	
Focused Teams Effort to Achieve Lowest Cost Design						S/I			R	✓	✓	✓	✓	
Value Engineering														

S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-7

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Streamlined Management

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Reduced Levels of Management		S		S	S	M/I			R		✓	✓	✓	
Simplify Interfaces			S	S	S	S/I			R		✓	✓	✓	
Clarity of Responsibility			S	S	M	S/I			R		✓	✓	✓	
Drive Integration Function to Lower Levels Through Concurrent Engineering				M	M	S/I			R		✓	✓	✓	
Reduce Bureaucracy/Meeting/ Approval Levels			S	S	S	S/I			R		✓	✓	✓	
Reduce Change				S		S/I			R		✓	✓	✓	

S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-13

NLS Program Manager/Contractors Review

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Relaxed Materials and Parts Specification

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Maximize Use of Contractor Specs & Processes			M	M	M	S/I	M		R	✓	✓	✓	✓	
Change From Grade 1 to Grade 2 or 2+ Parts			S	S	S	S/I	M		R	✓	✓	✓	✓	
Reduced Traceability, Testing & Documentation			S	S	S	S/I	M		R	✓	✓	✓	✓	
Reduced Configuration Control			M	M	M	S/I	M		R	✓	✓	✓	✓	

S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-12

2511-100

NLS Program Manager/Contractors Review

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Intensified Development Prior to Phase C/D

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Focus on Requirements and User Needs			M	S		S/I			R		✓	✓	✓	
Develop Preliminary Designs with Margins				M		S/I			R	✓	✓	✓	✓	
Maximize Off-The-Self Hardware						S/I			R		✓	✓	✓	
Perform Extensive Cost Trades & Sensitivities						S/I			R		✓	✓	✓	
Establish Realistic Cost Baseline				M		S/I			R		✓	✓	✓	
Reduce Changes in ø C/D Utilize Advanced Development/SRT to Mature Technologies			M	M		S/I			R		✓	✓	✓	

S = Significant Role
M = Minor Role
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R = Respond

2511-14

NLS Program Manager/Contractors Review

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Reduced Government Reporting Requirements

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Delete Excessive Documentation/ Minimizing CDRL / DRs				M	M	S/I			R	✓	✓	✓	✓	
Maximize Utilization of Contractor Documentation				M	M	S/I			R		✓	✓	✓	
Avoid OverSpecified & Constrained Solutions						S/I			R	✓	✓	✓	✓	
Reduced C / SPEC & PMS Requirements					M	S/I			R		✓	✓	✓	
Maximize Use of Computerized Reporting						S/I			R	✓	✓	✓	✓	

S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-10

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Stabilized Multiyear Funding

ITEM	Congress	NASA Administrator	Associate Administrator	Program Director	Center Director	Project Manager	Procurement	Comptroller	Contractor	AREA AFFECTED				
										SPECS	RFP	Proposal	Contract	Other
Multi-Year Funding Approval	S	S	S	M	M	S/I		S	R		✓	✓	✓	

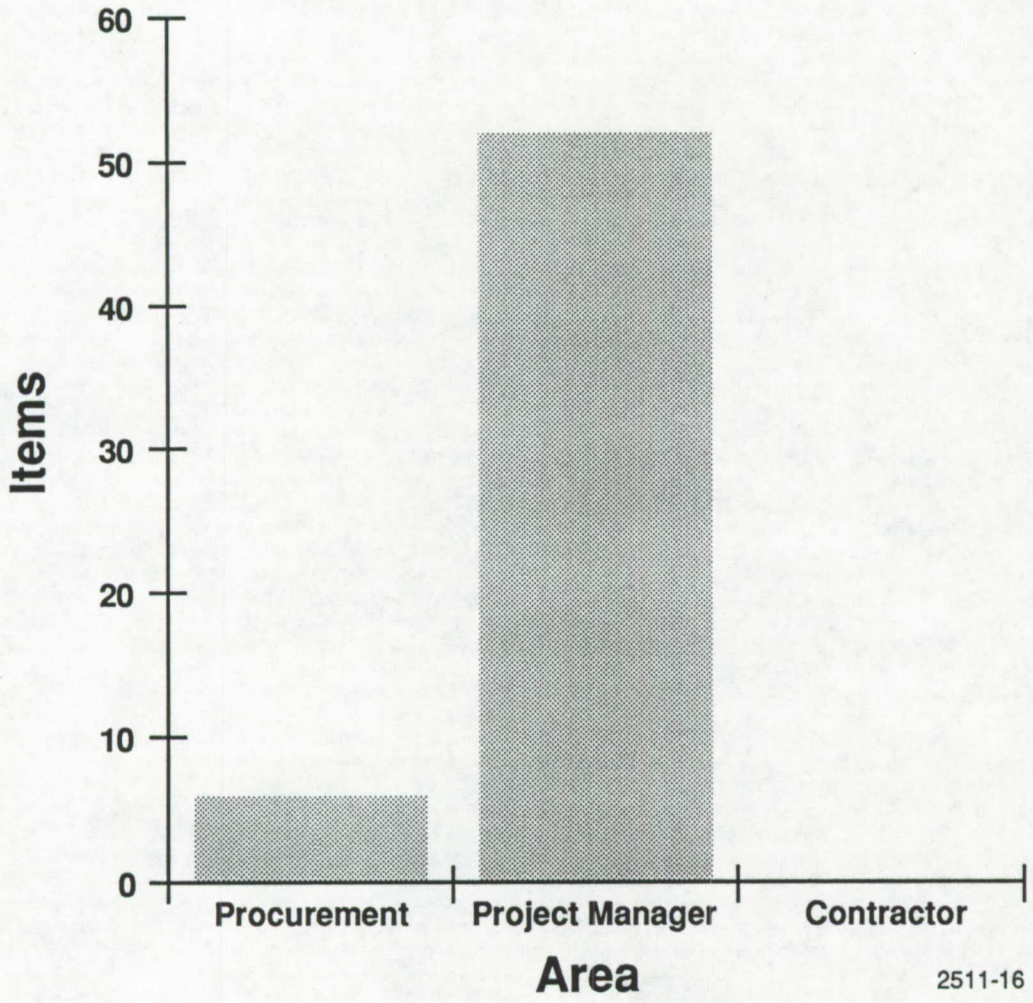
S = Significant Role
M = Minor Role
I = Initiator
R = Respond

2511-8

NLS Program Manager/Contractors Review

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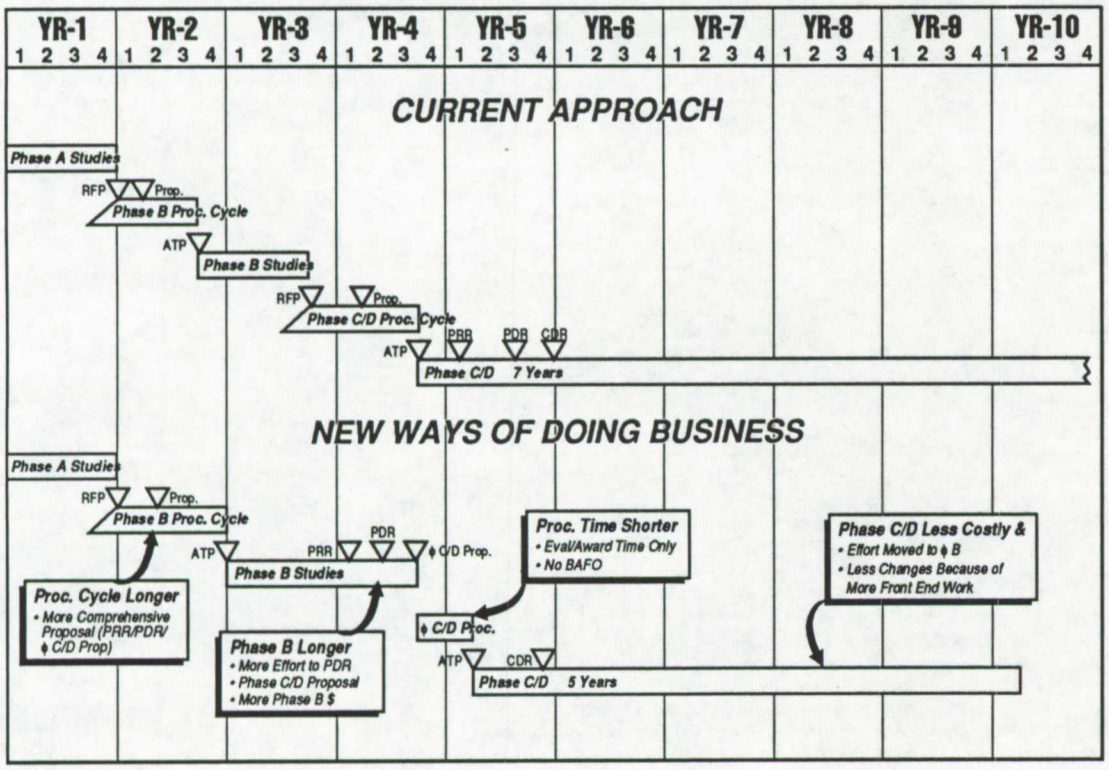
Initiators



NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Limitations of New Ways of Doing Business



2511-6

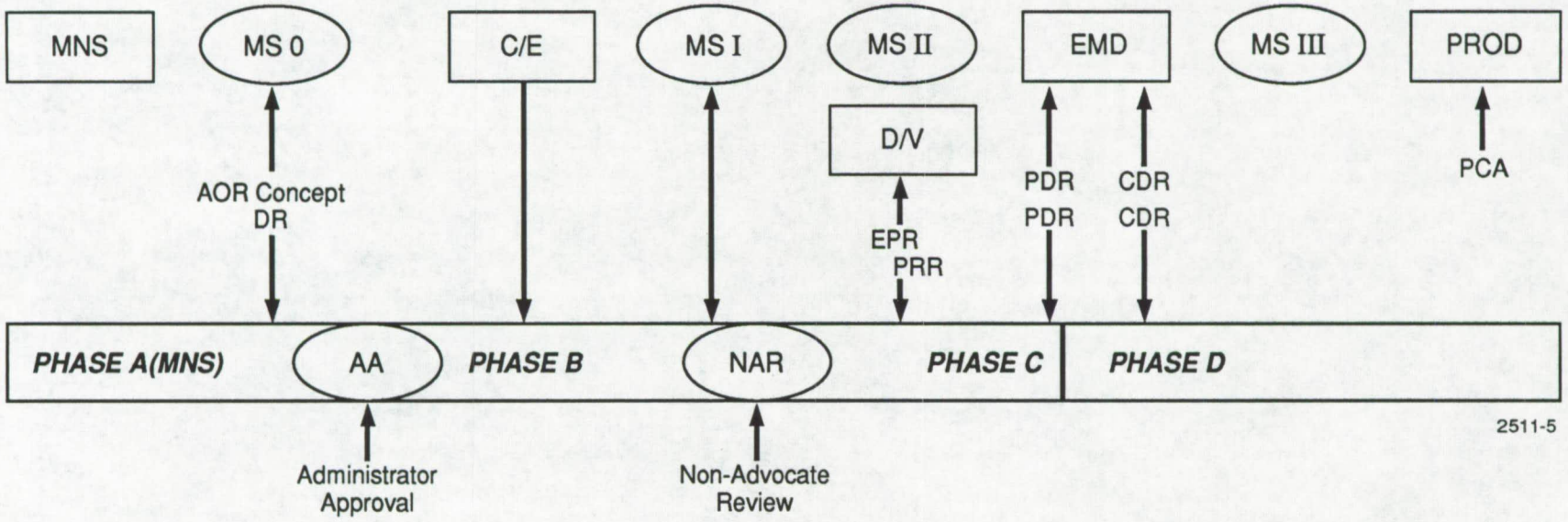
Real But Limited Improvements

- **10 to 20 percent schedule improvement**
- **10 to 30 percent cost reduction**
- **Takes time, motivation, effort, and training to define and implement**
- **Requires redefinition of Phase B function, goals, and deliverables**

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

DOD and NASA Program Acquisition Phasing



- **NASA system may be more flexible**
- **Agency-to-agency documentation is comparable but different**
- **Ideally, the implementing agency would use its own documentation/ specification**

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

View of NASA/DOD NLS Acquisition Strategy

- NLS is a "must win" for most U.S. aerospace companies
 - Early or late replacement of existing launch vehicle and components
 - Evolvable to future (PLS–SEI)
 - NASA, DOD, Commercial
- Shrinking DOD and space infrastructure
 - Titan, Atlas, Delta, STS → NLS
- Growing/subsidized international competition
 - ESA consortium
 - Japanese consortium
 - Russia/Ukraine—Commonwealth of Independent States
 - China
- What are the viable ways to satisfy U.S. national space infrastructure needs?
 - NLS consortium
 - Multiple/distributed contracts
 - Others?

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Criteria Against Which To Measure NLS Program Performance

- Is program faster, better, cheaper than any comparable alternative—all without compromising safety? Best value test?
- Does program satisfy NASA and DOD Level I requirements? Does it satisfy National Space Policy Directive #4?
- Is program structured to be manageable, controllable, and measurable?
- Are program content and rationale understandable to the U.S. public?
- Is program evolvable and adaptable to future evolutions?

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Engine-Out

- Engine-out requirement at Level I or Level II appears to be an inappropriate/misplaced criterion
- Reliability goal would be an appropriate requirement
- Specifying engine-out is potentially specifying an erroneous design solution
- Engine-out may be an appropriate point design solution—not likely an appropriate solution for all configurations
- However,
 - Engines should have health/performance instrumentation (vehicle health management)
 - Engines should be operated within robust margins (not beyond redlines)
 - Engine hold down—design to assure good engines at lift-off
 - All engines should be designed for benign shutdown
- Engine-out entails complex and involved analyses using valid data and criteria

NLS Program Manager/Contractors Review

UNITED TECHNOLOGIES USBI

Summary

- NLS's mooring lines seem to be loose
- Anxious to review/understand Red/Blue Teams' findings
- DOD/USAF funding is encouraging—hopeful of improved NASA funding
- View of USAF sharing funds is unclear
- Encouraged by new ways of doing business—but has limitations
- Begin to lay hard planning and tasks into place to selectively enter firm development

UNITED TECHNOLOGIES USBI

Engine-Out

- **Engine-out is a potential solution to Level II reliability requirements; it should *not* be specified as a requirement. Other means of meeting vehicle reliability are available.**
- **Contrary to the spirit of TQM, engine-out is the quality inspector at the end of the production line—an attempt to inspect in quality.**
- **As a design solution, engine-out is a complex function of both objective and subjective parameters.**
- **If engine reliability is sufficiently high, engine-out is not necessary to meet the Level II reliability requirement assuming the following:**
 - **Vehicle hold down**
 - **Engine health monitoring with benign shutdown**

1.2.6 Compilation of all Assigned Actions

Task report 1.2.6 is a compilation of all assigned actions from the Program and Contractors' Managers' Review (PCMR) #1 (November 6, 1991), PCMR #2 (January 15-16, 1992), PCMR #3 (March 19-20, 1992), and PCMR #4 (May 13-14, 1992). This report lists each action assigned, the actionee, and the action's disposition.

Compilation of Actions for NLS
July 8, 1992

Actions from 4th PCMR May 13-14:

20K Vehicle Implementation and Utilization
Actionee: Contractors
Disposition: Due at July PCMR

Justification for 50K Vehicle
Actionee: Contractors
Disposition: Due at July PCMR

Specific Scars for SEI
Actionee: Contractors
Disposition: Due at July PCMR

Complete Commercialization Chart (May PCMR)
Actionee: Contractors
Disposition: Due at July PCMR

Report of PDT's Performance
Actionee: Len Worlund
Disposition: Due at July PCMR

Impressions of Engine ICD
Actionee: Jerry Smelser
Disposition: Due at July PCMR

Conclusions from Programmatic and Technical Commercial Requirements
Actionee: Uwe Hueter
Disposition: Due at July PCMR

Actions from 3rd PCMR March 19-20:

Provide rationale for preferred approach to maintain industrial base until new start for vehicle and payload accommodations.
Actionee: Contractors
Disposition: Done March 31

S&E teams meet with contractor cost estimators on design-to-cost.
Actionee: Len Worlund
Disposition: Done March 27

Develop vehicle to engine Interface Control Document (ICD) with no TBD's.
Actionee: TBC, RI, STPT
Disposition: Done May 13-14

Determine how to evolve the NLS to meet SEI requirements.
Actionee: MMMSS, TRW, MMC
Disposition: Done May 13-14

Determine how to mature the phased budgeting approach considering the current acquisition plan.
Actionee: GD, RI
Disposition: Done May 13-14

Develop specific, objective items for doing business differently to lower costs.
Actionee: MDSSC, USBI
Disposition: Done May 13-14

Specify what technologies we need with respect to operations improvements along with their cost investment and savings.
Actionee: TBC, GD, LMSC
Disposition: Done May 13-14

Define Integrated Product Development Team (IPDT).
Actionee: TRW
Disposition: Done May 13-14

"Opportunities for Change":

Memo from Bridwell dated January 29, 1992. Attempt to identify and quantify those practices, required by both the government and by contractors, that drive developmental and operational costs in terms of time and money.
Actionee: Contractors
Disposition: Contractors presented ideas at the 2nd PCMR. Action continued to next PCMR

Agreements from 2nd PCMR January 15-16, 1992- Bridwell memo dated January 29, 1992:

Establish Working Group to:
1) allocate and monitor cost goals for hardware and software
2) resolve program requirements issues which drive cost.

Technical Decisions:
- STME vac Thrust increased to 650K (+3000# Payload)
- Core Intertank scars for HLLV deleted, i.e., 1.5 stage unique (+3500# Payload)
- Core LH2 tank length increased additional 5ft
- Adopt propellant dump thru STME for core deorbit (+3000# Payload)
- Add engine/feedline bleed system for prelaunch conditioning (+6000# Payload)
- Baseline STME Isp requirement @428.5sec (+3450# Payload) with goal @ 430.5sec

Actions from 1st PCMR on November 6, 1992 (Angie Jackman list):

Preparation and concurrence of NLS Position Book.
Actionee: H. Atkins
Disposition: Contractors gave inputs/comments

Establish cost tracking system.
Actionee: L. Zoller
Disposition: ?

Prepare schedule.
Actionee: L. Zoller
Disposition: Continuing updates

Concur in MOU/MOA (Level II Punch List).
Actionee: E. Gabris
Disposition: ?

Prepare Acquisition Plan.
Actionee: L. Zoller (M. Stiles) w/ design support from L. Worlund
Disposition: ?

Prepare Program Management Plan.
Actionee: L. Zoller (D. Thurman)
Disposition: Project Plan draft published May 5

STME (increase thrust, engine out, base heating considerations).
Actionee: J. Monk
Disposition: Technical descisions made January 15-16

Vehicle (1.5 performance, operations impact on design, incorporation of advanced technology, incorporation of 20K vehicle and propulsion requirements).
Actionee: L. Worlund
Disposition: Done March 19-20

CTV Punch List:
Reference Communications
Maximum use of existing hardware (avionics?)
Reusability
Propulsion parameters, performance
Mission duration
Dependence on SSF logistics supply mission
SSF and Orbiter imposed requirements.
Actionee: H. Buchanan
Disposition: ?

Requirements review.
Actionee: Level II
Disposition: Lv III Contractors made inputs - NASA compiled: Done June

OMB and National Space Council submittals:

1) NLS program management plan, acquisition plan and preliminary payload transition plan.

2) Options for reducing development and/or operations costs.

Actionee: NASA/DoD
Disposition: Lead by Level II

Support the Level II/TRW study of potential management concepts for program management and integration (JPO memo of November 27, 1992).
Actionee: TRW w/ MSFC support
Disposition: ?

Continuous Improvements Steering Council (J. Lee) questions (Schramm memo of November 26, 1992):

By what criteria do you judge our performance?

What are your expectations of the Center?

What are we doing that you believe is counter-productive or causing you unnecessary work?

In what areas do you think we should improve?

Actionee: Contractors
Disposition: Done - F. Shramm produced a summary

Actions from 1st PCMR November 6, 1991 (Bridwell list November 6, 1991):

Prepare project plan, logic network, schedules, cost assumptions, implementation philosophy.
Actionee: Each project w/ Contractors
Disposition: Project Plan, Network & Schedules: Drafts & updating

Plan for reducing launch processing without constraints of the STS procedures.
Actionee: D. Page (KSC) & J. Madewell (LMSC)
Disposition: ?

Establish means for setting cost targets and define a tool for measuring progress against the targets.
Actionee: L. Zoller
Disposition: ?

Assess viability of, and develop plans for, demonstrations as an integral part of the development program.
Actionee: L. Worlund
Disposition: USBI input in March-April

Col. Colgrove conclusions:

Colgrove will pursue the Acquisition Strategy, keeping open the option for a 1999 launch by adjusting funding levels and for content.

Colgrove to increase emphasis on operational requirements methodology.

Colgrove endorsed consideration of early demonstrations.

1.2.7 Project Management and Schedule Software Analysis

Task report 1.2.7 is a report titled, "Evaluation of Project Management and Scheduling Packages." This report documents the result of a review of program management and scheduling software packages and recommends a package to be used as a standard throughout the NLS program.

FOR GOVERNMENT USE ONLY

Evaluation of Project Management and Scheduling Packages

Final Report

prepared for:

The National Aeronautics and Space Administration
Heavy Lift Launch Vehicle Definition Office

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

prepared by:

Applied Research, Incorporated
6700 Odyssey Drive
Huntsville, Alabama 35806

Report Number ARI-92-R-013-21

May 1992

FOR GOVERNMENT USE ONLY

Executive Summary

This report documents the efforts of Applied Research Incorporated (ARI), under subcontract to United Space Boosters International (USBI), contract number NE3837145 (purchase order 42566), in support of the Heavy Lift Launch Vehicle (HLLV) definition office of the Marshall Space Flight Center (MSFC). Under this effort, ARI was tasked to review project management and scheduling software packages and recommend a package that could be used as a standard throughout the National Launch System (NLS) program. The period of performance of this task extended from January 1992 through April 1992.

Three matrices were developed for the evaluation: a criteria matrix which was used to rank the software packages from poor to excellent over a wide variety of features, a matrix that summarizes additional attributes of the software, and a matrix that contains the limits and capacities of the software.[1] The evaluation criteria were reviewed with MSFC to determine the relative importance of each criteria based upon their preferences and needs. The matrices were used to collect data during the evaluation process and to aid in the final software assessment. In addition, our findings were supplemented through interviews with technical support personnel and users of the software.[2]

The software evaluation was completed in three stages. Stage 1 began in early January and continued until January 27 when the preliminary assessment was delivered. The Stage 1 assessment included the review of Mac Project II, FastTrack Schedule, and ARTEMIS Schedule Publisher software packages. The recommendations that resulted from Stage 1 included: eliminating FastTrack and Mac Project II from further study, evaluating ARTEMIS Schedule Publisher in greater detail, and adding Micro Planner X-Pert and Open Plan/Mac to the assessment.[3] These three packages were reviewed in Stage 2 which continued until February 18 when an interim report was submitted. At that time, the study efforts were temporarily delayed to fulfill a more pressing need for the NLS Program Master Schedule and logic network. Microsoft Project and Project Scheduler 4 (PS 4) were also added to the assessment for stage 3.[4]

In stage 3, demonstration packages of Microsoft Project and Project Scheduler 4 were reviewed in detail.[5] When we completed this review, we expanded the three matrices to include all of the packages from stage 2 and stage 3 (Microsoft Project, Project Scheduler 4, Micro Planner X-pert, Open Plan/Mac, and ARTEMIS Schedule Publisher). We used

[1] A partial display of these matrices is contained in Figure 1.2.
[2] Figure 1.1 on page 2 displays the task methodology.
[3] Refer to Section 2.2 for a description of Stage 1.
[4] Refer to Section 2.3 for a description of Stage 2.
[5] Refer to Section 2.4 for a description of Stage 3.

the relative importance ranking provided by MSFC in conjunction with our assessment of the criteria features to develop our recommendation. Our intent was not to find the "perfect package", but to find the most balanced package that would provide the user with top quality features and performance.

Of all the packages reviewed, Micro Planner X-Pert demonstrated above average ratings by remaining consistently flexible and easy to use. Being the most balanced package that we reviewed, we recommend it to support the project management requirements of the NLS program.[6]

[6] Refer to Section 3.2 for a detailed discussion of the results.

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1.0 INTRODUCTION

This report documents the efforts of Applied Research Incorporated (ARI), under subcontract to United Space Boosters International (USBI), contract number NE3837145 (purchase order 42566), in support of the Heavy Lift Launch Vehicle (HLLV) definition office of the Marshall Space Flight Center (MSFC). Under this effort, ARI was tasked to review project management and scheduling software packages and recommend a package that could be used as a standard throughout the National Launch System (NLS) program. This report documents the task and includes:

- an executive summary that provides the reader with the task overview and study results;
- a methodology section that includes the task ground rules and assumptions, and the criteria matrices used to evaluate the software;
- a results and recommendations section that includes definitions for each of the criteria in the matrix, a completed version of the criteria matrix where the software packages are ranked from poor to excellent over a wide variety of features, a matrix that summarizes additional attributes of the software, a matrix that contains the limits and capacities of the software, and a discussion of our recommendations; and,
- Appendix A that includes the supplemental sources of information used in the evaluation.

1.1 Accomplishments During the Period of Performance

The period of performance of this task extended from January 1992 through April 1992. An interim report was delivered on February 18 and, at that time, the study efforts were temporarily delayed to fulfill a more pressing need for a NLS Program Master schedule and logic network. The software assessment was completed with the concurrent development of the schedule and logic network during the March and April time frame. Additional time could have *easily* been spent studying the attributes of each software package in the evaluation. The intent of the task, however, was to quickly and efficiently review the software so that the HLLV office could begin scheduling and planning the program.

2.0 METHODOLOGY

The software evaluation was completed in three stages. Figure 1.1 provides an overview of the task methodology and indicates the activities that were performed during each stage of the task. The three stages occurred during separate time periods.

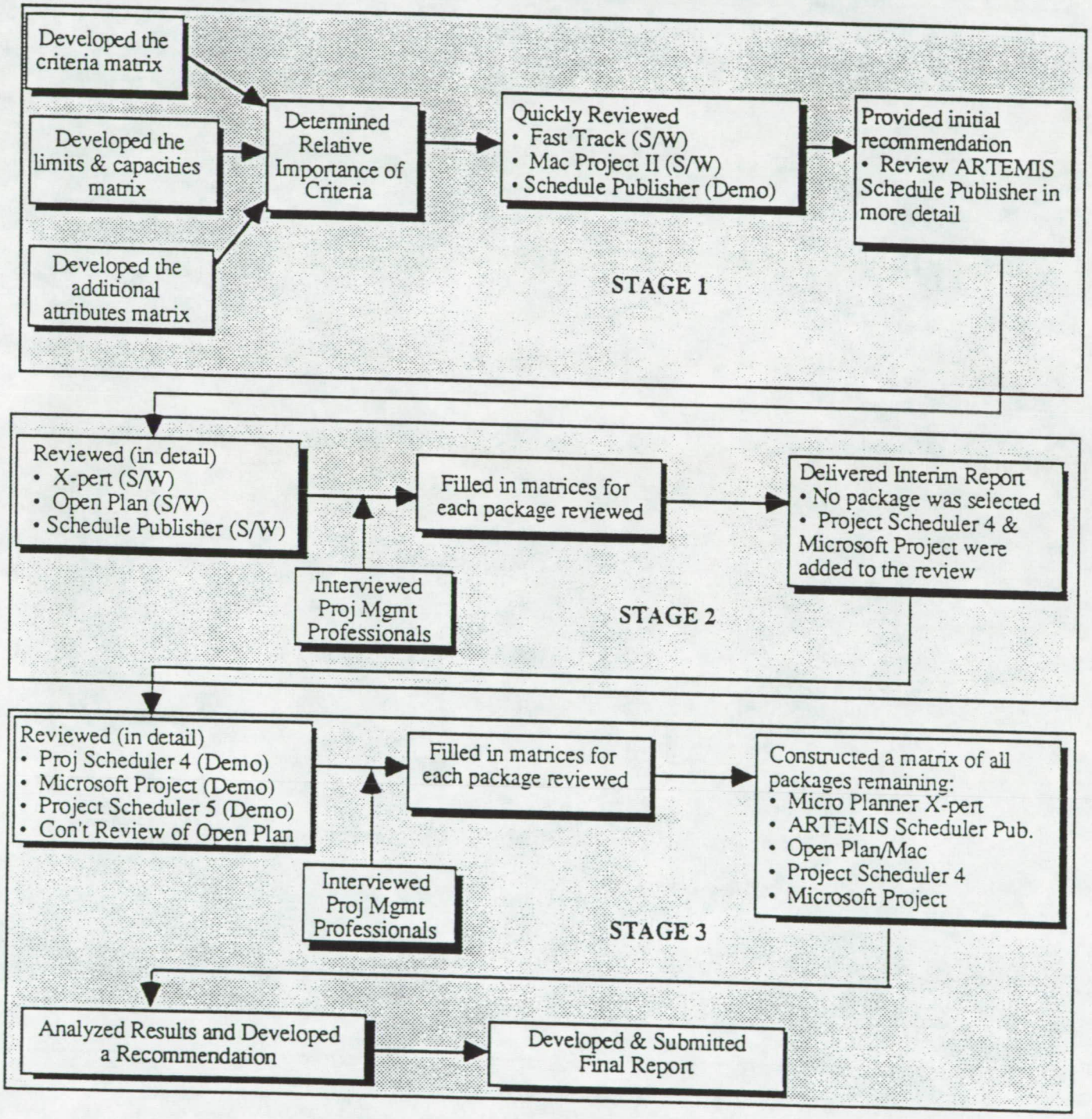


Figure 1.1 Task Methodology

2.1 Ground Rules and Assumptions

Prior to beginning Stage 1, we developed the following list of ground rules and assumptions which were agreed to by the responsible MSFC Manager:

- only Macintosh resident packages would be considered for review;
- an overview analysis would be conducted for: MacProject II, Fast Track Schedule, and ARTEMIS Schedule Publisher;
- any one of these packages would automatically be eliminated from further review if they did not satisfy a highly weighted criteria;
- an in-depth analysis would be conducted of additional TBD software packages; and,
- the cost of additional hardware requirements for HLLV that could potentially result from the software recommendation would not be estimated.

2.2 Stage 1

Stage 1 began in early January and continued until January 27 when a preliminary assessment was delivered. In stage 1, we began by developing a criteria matrix and reviewing the criteria with MSFC to determine the relative importance of each criteria based upon their preferences and needs. Our intentions were not to assign a weighted value to the criteria, but simply to understand how the criteria ranked in terms of importance to the ultimate user. As we developed this list, it was evident that not all of the items we were generating qualified as "criteria." We decided to separate the subjective criteria from those that simply identified features, limits, or capacities. In total, we developed three matrices: the criteria matrix, the limits and capacities matrix, and the additional attributes matrix. Figure 1.2 displays samples of these matrices.

CRITERIA	X-pert	Sched. Pub.	Open Plan	Proj Sched 4	MicroSoft Project
Flexibility of Importing/Exporting					
Help Screens					
Manuals					
Menus					
Overall Performance and Reliability					
Overall Scheduling Capabilities					
Real Time Analysis for Schedules and Networks					
S/W Support Quality					
Support Accessibility					
Tutorial					
User Interface					
Etc.....					

LIMITS and CAPACITIES	X-pert	Sched. Pub.	Open Plan	Proj Sched 4	MicroSoft Proj
No. of Subprojects					
No. of Activities per Project					
Description Field Length Limit					
No. of Schedule Summary Structures					
No. of WBS/OBS Summary Structures					
Min. Duration Planning Unit					
No. of Different Calendars					
No. of Resource Types					
No. of Resources per Activity					
No. of User Available Text Fields					
Etc.....					

ADDITIONAL ATTRIBUTES	X-pert	Sched. Pub.	Open Plan	Proj Sched 4	MicroSoft Project
Availability of Gantt Chart Views					
Availability of PERT Diagram Views					
Availability of Resource Histograms					
Availability of Split Screens					
Availability of Structure/Tree diagrams					
Availability of Spreadsheet-type task lists					
Critical Path Method Analysis					
Multiple Start and End Nodes					
PERT Analysis					
Compatible with JPO/BMO					
Compatible with Macintosh System 7					
Etc.....					

Figure 1.2 Evaluation Matrices

We then conducted an overview evaluation of MacProject II, FastTrack Schedule, and ARTEMIS Schedule Publisher. Full versions of the software were used to evaluate MacProject II and FastTrack and a demonstration package was used to evaluate ARTEMIS Schedule Publisher. Conducting the review with the knowledge of which criteria were most important to the customer, it quickly became evident that MacProject II and FastTrack Schedule would not suffice their needs. We delivered a preliminary assessment that summarized our findings and presented recommendations for the remainder of the task. The highlighted results of this assessment are discussed below.

Fast Track Schedule (Version 1.5)

Fast Track Schedule has many benefits as a scheduling tool; however, it does not provide the networking and resource tracking capability that is required. We recommended that the software be eliminated from further review.

ARTEMIS Schedule Publisher (Demonstration Package Version 3.0)

ARTEMIS Schedule Publisher has many benefits as a scheduling and project management tool. It seems to provide many of the scheduling, networking and resource tracking capabilities that are desired. We recommended that a full version of the software be obtained and reviewed in detail.

MacProject II (Version 2.01)

Mac Project II has many benefits as a scheduling and project management tool. It provides many scheduling, networking, and resource tracking capabilities; however, the constrictive activity limitation of 500 makes it a poor choice for further review.

Additional Recommendations

We also recommended that Micro Planner X-pert and Open Plan/Mac be added to the review.

2.3 Stage 2

In stage 2, we reviewed, in detail, full versions of ARTEMIS Schedule Publisher, Micro Planner X-pert, and Open Plan/Mac. During the review, we gathered the data for the attributes and limits and capacities matrices first, and then proceeded through the "tutorial" or "getting started" section of the software's documentation. As time allowed, we ran a test schedule and logic network to test features that were either absent or covered vaguely in the tutorial. We supplemented our findings by interviewing project management professionals which included technical support personnel and user's of the software. On February 18, we submitted an interim report that documented our findings. At that time we did not make a recommendation because the Open Plan/Mac[7] data was incomplete, there were two more packages added to the review, and there were some unresolved issues.

The interim report marked the end of stage 2. As mentioned in Section 1.1, when the interim report was delivered, efforts were postponed to create the NLS Program Master Schedule. The continuation of the software evaluation was delayed until the second week of March. Also, at that time, Microsoft Project and Scitor Corporation's Project Scheduler 4 were added to the assessment.

2.4 Stage 3

In stage 3, we reviewed, in detail, demonstration versions of Project Scheduler 4, Project Scheduler 5 (PS 5 for the PC), and Microsoft Project and continued the review of Open Plan/Mac.[8] It is important to note that Project Scheduler 5 for the PC was included in the review *only* because the Macintosh version of PS 5 had not been released at the time of the study. We were aware that Project Scheduler 4's activity capacity limitation of 2500 would limit our scheduling and networking flexibility; however, plans for the yet to be released PS5 Macintosh version included an activity capacity limitation of 7500. We were attempting to obtain some insight into PS5 since the Macintosh and PC versions

[7] Open Plan/Mac is a shell that runs with the accompaniment of Fox Base software which is a data base program. There was some delay in receiving Fox Base, which truncated the time that we had allocated to review Open Plan. The Open Plan/Mac data was incomplete and, at that time, it would have been premature to make a recommendation.

[8] There was no additional review of Micro Planner X-pert and ARTEMIS Schedule Publisher in Stage 3. The results of their evaluations were analyzed at the end of Stage 3 along with the data collected for Microsoft Project, Open Plan/Mac, and Project Scheduler 4.

were taunted as being quite similar. We supplemented our review of Project Scheduler 4 with the data that we collected from reviewing Project Scheduler 5.

The review in stage 3 was conducted in a similar fashion to that in Stage 2. We completed the attributes and limits and capacities matrices first and then proceeded through the "tutorial" or "getting started" section of the software's documentation. Once again, we supplemented our findings by interviewing technical support personnel and user's of the software. When we completed reviewing Project Scheduler 4 and 5, Microsoft Project and Open Plan/Mac, we expanded the matrices to contain the software packages from stage 2 and stage 3. We studied all of the data, cross referenced the data to our hands-on experience with each package, and made an assessment for each of the criteria in the matrix.[9]

[9] A dictionary of the criteria listed in the matrix is included in section 3.1.

3.0 RESULTS AND RECOMMENDATIONS

3.1 Criteria Description

During the review and evaluation process, we studied the data collected in each of the matrices as well as the data that we collected from other sources.[10] The limits and capacities and additional attributes matrices were used to gather software features and specifications. The terms used in these matrices are self explanatory. The criteria matrix was used to rate each of the software packages from poor to excellent over a wide variety of topics i.e. capacity; scheduling and resource controls; planning and tracking capabilities; and editing and reporting features. To aid in our evaluation, we found it very useful to list questions for each item in the criteria matrix. To help the reader properly interpret the evaluation results, we have included this list below. Figure 3.1 describes the rating scheme used in the criteria matrix.

• Symbol	=	Heart (❤)
• Poor	=	1
• Fair	=	2
• Good	=	3
• Very Good	=	4
• Excellent	=	5

Figure 3.1 Criteria Matrix Rating Scheme

Flexibility of Importing/Exporting:

What are the available file formats for importing and exporting? How much data is importable/exportable? Are there any direct interfaces built with the software? How difficult is the importing/exporting?

Help Screens:

Are the help screens easily accessible? Are they indexed? How easy is it to locate a particular topic? Is the information that they provide thorough? Do they cross reference to other topics?

[10] Refer to Appendix A for a complete list of supplemental sources.

Manuals:

How organized is the manual? Is there an overload of information? Is the text easy to understand and follow? How well does the manual graphically display examples of screen formats or reports? Is the manual indexed? Does it contain examples? Can you quickly and easily locate a specific topic?

Menus:

Are the menus user friendly? Are they typical Macintosh? Are the menus intuitive?

Overall Performance Reliability:

Does the software operate at a reasonable processing speed? Are there any noticeable bugs in the software?

Overall Scheduling Capabilities:

Are there any limitations to the scheduling capabilities? How diverse are the scheduling functions? Is it easy to generate a schedule? Are the data inputs for the schedule cumbersome? Is it easy to change the schedule?

Real-time Analysis for Schedules and Networks:

Can impacts of changes in the data (schedule or logic network) be automatically viewed on the screen or does the user have to recalculate the schedule (or network) before viewing change impacts?

Software Support Quality:

What level of technical support is available? Are the technical personnel responsive and knowledgeable? Were the calls answered promptly and correctly?

Support Accessibility:

How easy is it to contact the technical support personnel? Is there a toll free number available? Is there a fax number to send inquiries?

Tutorial:

Does the software follow along with the tutorial? Does the tutorial highlight the major features of the software? Is it logically organized? Are there cross references to the user's guide or reference manual?

User Interface:

How does the software rate overall for ease of use => taking into account menus, help screens, manuals, and the operating environment?

Control over fonts, text, patterns, colors etc.:

Is there a wide variety of fonts, patterns and colors available to the user? Are the fonts, text, patterns, colors, easy to change? Can the user create custom bars and symbols?

Diversification of Standard Reports:

How many standard reports are available to the user? Do the standard reports offer a wide variety of reporting options? Do they meet the needs of the user?

Manipulation of Standard Reports:

To what extent can the standard reports be manipulated? Can the graphics be changed or only titles and legends?

Ease of Calendar Adjustment:

How easy is it to adjust the calendar? Are there a wide variety of calendar default options to aid the user in changing the calendar? Is it easy to adjust from calendar years to fiscal years and vice versa? Can weekends and holidays easily be suppressed?

Ease of Changing and Manipulation of Graphics:

Is it easy to change on-screen graphics? Can the reports be changed while working within the software or do they have to be exported to a drawing package for editing?

Ease of Entering Data:

Is data entry a simple process? Is there a single data entry screen used for all data input? Is there a logical sequence for entering data across screen formats? What are the available formats for entering data?

Ease of Report Creations:

Does the software allow you to create custom reports? Can the custom reports be created from within the software or is an external drawing package required? How easy is it to create a custom report?

Ease of Use Before Training:

How easy is it to use the software before any formal training? Does the documentation aid you sufficiently in this area? Is the nomenclature standard? Is there an abundance of software proprietary terminology?

Ease of Statusing:

Can the project status be updated while in the Gantt or Logic Network on-screen view? How easy is it to post progress? Can the user view the progress updates on the screen?

Editing of Spreadsheet-type Task Lists (Table format):

Is it easy to edit the spreadsheet-type format? Can you use *cut, copy, paste, insert, find, sort, etc.*, and similar functions in the table format?

Flexibility of Data Entering Across Screen Formats:

Can data be entered in all screen formats i.e. Gantt, Logic Network, Table, etc.,.,.,? Is there a capability to split screens so that more than one screen can be viewed at a time?

Flexibility To Handle Diverse Projects:

What is the software's capacity and relative speed? Is the project architecture flexible to handle large projects? Can you break the project data into subprojects? Can you interface subprojects and projects?

Quality of Graphical Output:

What is the quality of the software's graphical output? for the Gantt? for the Logic Network? Does the software support a wide variety of output devices?

Ease of Resource Management:

Can common resources be shared across projects? Can resources be assigned per task? Will the software support automatic resource leveling? Can the user prioritize the resource leveling process?

Flexibility of Reporting Features:

How much flexibility is there for the user to create custom reports? Does the software support batch reporting?

3.2 Study Results

It was not our intent to determine the "perfect" package, but to find the most "balanced" package that would provide the user with top quality features and performance. Figures 3.2 and 3.3 display the software attributes, limits, and capacities data that we collected, and Figure 3.4. contains our evaluation for each of the packages reviewed. The discussion below highlights the advantages and disadvantages of the software.

Micro Planner X-pert

Micro Planner X-pert has many advantages and is a well balanced software package. Its "user friendliness" is obvious in the well organized, well written and well indexed manuals; easy to use, intuitive, and typical Macintosh menus; and simple and convenient data entry formats. The user can change schedule information and resource assignments from within the same data entry form and entering data in the schedule, network, and table views is consistently simple. The "Mac like" project desktop working environment provides a welcomed familiarity to the user. Micro Planner X-pert offers great flexibility in reporting features by allowing the user to easily manipulate the software's standard reports through the use of the "Standard Report Stationery" or access the built in report generator to produce customized reports with excellent quality. The software lends itself to large projects because of its generous data capacity of 10,000 activities and project architecture which provides the user with the capability of dividing large projects into more manageable subprojects.

Unfortunately, this capability has some drawbacks. The networks are built at the subproject level, the subproject activity capacity is 1400, and the subprojects are connected through the use of interface nodes. This subproject capacity limitation forces the user to visualize the entire project network and plan the division or segmentation of the network early in the design. This knowledge is not always available in the early stages of a program. In addition, to consolidate the subproject networks into one graphical representation (for plotting the entire network), the user must save the data to an external file (PICT file).

ADDITIONAL ATTRIBUTES	X-pert	Sched. Pub.	Open Plan	Project Sched. 4	MicroSoft Project
Availability of Gantt Chart Views	✔	✔	✔	✔	✔
Availability of PERT Diagram Views	✔	✔	✔	✔	✔
Availability of Resource Histograms	✔	✔	✔	✔	✔
Availability of Split Screens	✔	✔		✔	✔
Availability of Structure/Tree diagrams	✔		✔		✔
Availability of Spreadsheet-type task lists	✔	✔	✔	✔	✔
Critical Path Method Analysis	✔	✔	✔	✔	✔
Multiple Start and End Nodes	✔	✔	✔	✔	✔
PERT Analysis	✔			✔	✔
Accomodation of different logic types (FS,FF,SS)	✔	✔	✔	✔	✔
Comparison of Actual Performance to Planned - Cost	✔		✔	✔	✔
Comparison of Actual Performance to Planned - Schedule		✔	✔	✔	✔
Integration of Multiple Schedules	✔	✔	✔	✔	✔
Search/Replace by activity in a schedule		✔	✔		✔
Can the calendar accommodate a Fiscal Year	✔	✔	✔		
Can you suppress weekends and holidays	✔	✔	✔	✔	✔
Can the calendar by adjusted per resource	✔	✔	✔	✔	✔
Ability to Level Resources Automatically	✔	✔	✔	✔	✔
Ability to Prioritize Resource Leveling Process	✔	✔	✔	✔	✔
Ability for Common Resources to be Shared Across "Projects"	✔	✔	✔	✔	✔
Network Capable	✔	✔	✔		✔
Compatible with JPO/BMO	✔	✔	✔	✔	
Compatible with Macintosh System 7	✔	✔	✔	✔	✔



Figure 3.2 Software Attributes



LIMITS and CAPACITIES	X-pert	Sched. Pub.	Open Plan	Project Sched. 4	MicroSoft Project
No. of Subprojects	50	0	0	0	255
No. of Activities per Project	10,000	4,000	10,000	2,500	2000 and with a 1MB MAC1000
Description Field Length Limit (character length)	254	63 2 lines	30 Default 256 (unlimited)	30 40	80
No. of Schedule Summary Structures	1	Unlimited	10	10-20	Varies
No. of WBS/OBS Summary Structures	Unlimited	0	2	10-20	
Min. Duration Planning Unit (i.e. minute, hour, day, etc.,)	Minute	Minute	Minute	Minute	Minute
No. of Different Calendars	Unlimited	Unlimited	256	Unlimited	255
No. of Resource Types	200	254	500	500	2000
No. of Resources per Activity	20	254	250	Unlimited	20
No. of User Available Text Fields	1	100	Unlimited	1 (Free Format)	2 for Resources 6 for Tasks
No. of Calendar Years (project date range)	1952 - 2039	1965 - 2035	1980-2499	1981-2019	1984-2049
No. of Activity Bar Shade Patterns	40	40	8		13
No. Start/Finish Symbol Types	unlimited	7	30	2	15
No. of Activity Bar Styles	unlimited	300	16	2	7
No. of Activity Bar Colors	8	8	16	3	8
No. of Work Breakdown Structure Elements	1,000	0	10 Levels	10 Levels	1 Level
WBS element name length (character length)	12	0	40 Defaults 256 (unlimited)	10	80
No. of Standard Reports	11	100	65	9	12
Formats for Importing and Exporting Data	MacProject II InstaPlan (DOS) MICRO-PLANNER DIF, ASCII	Excel Lotus 1-2-3 ARTEMIS PrimaVera ASCII	MacProject II COESDE Time Line Open Plan-VAX ASCII	Excel Lotus 1-2-3 CSV ASCII	Excel Lotus 1-2-3 TxT, TSV CSV, dBase
How much data is Importable and Exportable	ALL	ALL	ALL	ALL	ALL Except Status

Figure 3.3 Software Limits and Capacities

CRITERIA	X-pert	Sched. Pub.	Open Plan	Project Sched. 4	Micr[illegible] Project
Flexibility of Importing/Exporting	❤❤❤❤	❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤
Help Screens	❤❤❤	❤❤❤	❤❤❤	❤❤❤	❤❤❤
Manuals	❤❤❤❤❤	❤❤❤	❤❤	❤❤❤	❤❤❤
Menus	❤❤❤❤	❤❤❤	❤❤	❤❤❤	❤❤❤
Overall Performance and Reliability	❤❤❤❤	❤❤❤❤	❤❤❤	❤❤❤❤	❤❤❤❤
Overall Scheduling Capabilities	❤❤❤❤	❤❤❤❤❤	❤❤❤❤	❤❤❤	❤❤❤
Real Time Analysis for Schedules and Networks	❤❤❤❤	❤❤❤❤	❤	❤❤❤	❤❤❤
S/W Support Quality	❤❤❤	❤❤❤❤	❤❤❤	❤❤❤	❤❤❤❤
Support Accessibility	❤❤❤❤	❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤❤❤
Tutorial	❤❤❤❤❤	N/A	❤❤❤	❤❤❤	❤❤❤
User Interface	❤❤❤❤❤	❤❤❤❤	❤❤	❤❤❤	❤❤❤
Control over Fonts, Text, Patterns, Colors, etc.,	❤❤❤❤❤	❤❤❤❤❤	❤	❤❤❤	❤❤❤❤
Diversification of Standard Reports	❤❤❤	❤❤❤❤❤	❤❤❤❤	❤❤❤	❤❤❤
Manipulation of Standard Reports	❤❤❤❤❤	❤❤❤	❤❤❤	❤❤❤	❤❤❤
Ease of Calendar Adjustment	❤❤❤❤❤	❤❤❤❤	❤❤❤	❤❤❤❤	❤❤❤
Ease of Changing and Manipulating Graphics	❤❤❤❤	❤❤❤❤	❤❤	❤❤❤❤	❤❤❤❤
Ease of Entering Data	❤❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤	❤❤❤❤
Ease of Report Creation	❤❤❤❤❤	❤❤❤	❤❤❤	❤❤❤	❤❤❤❤
Ease of Statusing (Posting Process)	❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤❤	❤❤❤❤❤
Ease of Use Before Training	❤❤❤❤❤	❤❤❤❤	❤❤	❤❤❤	❤❤❤
Editing of Spreadsheet-type Task Lists (Table Format)	❤❤❤❤	❤❤❤❤	❤❤❤❤❤	❤❤❤❤	❤❤❤❤
Flexibility of Data Entry Across Screen Formats	❤❤❤❤	❤❤❤❤	❤❤	❤❤❤❤	❤❤❤❤
Flexibility to Handle Diverse Projects	❤❤❤❤❤	❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤
Quality of Graphical Output	❤❤❤❤❤	❤❤❤❤❤	❤❤❤	❤❤❤❤	❤❤❤❤
Ease of Resource Management	❤❤❤❤	❤❤❤	❤❤	❤❤❤❤	❤❤❤
Flexibility of Reporting Features	❤❤❤❤❤	❤❤❤❤❤	❤❤❤❤	❤❤❤❤	❤❤❤❤

NASA

Figure 3.4 Software Evaluation Results



Applied Research, Inc.

ARTEMIS Schedule Publisher

ARTEMIS Schedule Publisher defines a simple approach to project scheduling in a user friendly environment. The software opens to a full screen Gantt view where an inexperienced user can quickly create a schedule entirely through the use of the mouse. Schedule updates, such as changing activity durations and posting progress can effortlessly be completed in a similar fashion. The software provides real time feedback for schedule changes because it automatically calculates the project end date when the user makes a change to an activity duration. ARTEMIS Schedule Publisher offers the user reporting flexibility through the use of MacDraw or Canvas where the user can create custom reports with excellent quality. It also provides comprehensive data exchange facilities for the 6000, 7000, and 9000. ARTEMIS platforms.

Unfortunately, when the user moves outside of the Gantt environment, the menu choices become less obvious. The menu descriptions are confusing and their non-intuitive nature can be frustrating. ARTEMIS Schedule Publisher provides a manual method of resolving resource conflicts, but lacks automatic resource leveling which implies manual adjustment and can be extremely cumbersome for complex projects. Unfortunately, the use of MacDraw and Canvas for reporting purposes is sometimes inconvenient for the user because these packages reside external to the software. In addition, to produce these customs reports, the user is required to purchase the drawing package.

Open Plan/Mac

Open Plan/Mac is a very powerful software package with some impressive features. These features include: the data reporting capabilities which are a direct result of the software's external Welcom Reporting Language (WRL); the flexibility of importing and exporting; the quantity of data that the user can process; and the functions (i.e. sort, search, copy, paste,) available to the user for the manipulation of the data. The latter two features would not be possible without the presence of Fox Base which is a data base program that runs with Open Plan/Mac.

Unfortunately, these powerful features come with many sacrifices. Data entry is a confusing procedure and the absence of a Graphical User Interface (GUI) ensures nearly no graphical feedback. The software lacks real time analysis which makes examining change impacts frustrating because the user has to

recalculate every time a change is made to view the result. When the on-screen graphics appear, they are very difficult to read. The menus are not intuitive nor are they familiar to the typical Macintosh user. The WRL report generator is difficult to learn and can be overwhelming for a user without data base experience. The two volume set of manuals do not provide relief because they lack organization, contain very few examples, and read like a text book.

Project Scheduler 4

Project Scheduler 4 is a promising package with many solid features. One strength is its ability to organize project tasks into related groups using Work Breakdown Structures (WBSs), Organizational Breakdown Structures (OBSs), or Resource Breakdown Structures (RBSs) which requires the user to design the project layout prior to data entry. PS4 also has continuous rescheduling, and solid resource allocation tools among its strengths. It provides the user with the option of choosing interactive or automatic resource leveling which automatically shifts dates to help accommodate overloaded resources. It also allows the user to conduct "what-if" analyses by expressing the duration of a job in most -likely, optimistic or pessimistic values and then viewing the overall impact on the schedule.[11]

Unfortunately, for the experienced Macintosh user, accessing many of these PS4 functions is awkward. The menus and data entry formats are examples of areas where PS4 exhibits its DOS influence. The user is immediately introduced to this awkward environment when they open the software and a blank Gantt chart, logic diagram, and job template window appear. At this point, however, the user cannot enter data into either the Gantt or logic views and "what to do next" is not intuitively obvious. PS4 also reveals its DOS roots through its heavy dependency on codes i.e. WBS, OBS, RBS, and ds (days), hs (hours) which are used to define resources. In addition, the WBS, OBS and RBS structures cannot graphically be displayed on the screen. Even though PS4 has some impressive scheduling features it does not provide time limited scheduling and does not support project or task prioritization. The software also has a constricting capacity limitation of 2500 activities which significantly decreases its capability to handle a complex project.

[11] The IBM version of Project Scheduler 5 had some very impressive features; however, during the time frame of this evaluation the Macintosh version was not available to review.

ORIGINAL PAGE IS
OF POOR QUALITY

Microsoft Project

Microsoft Project is a flexible tool with many project management features. Its flexibility is evident in the diversity of scheduling constraints, reporting features and schedule outlining capabilities that it provides the user. Microsoft Project supports eight scheduling constraints and allows the user to view data in a variety of ways by using custom tables and filters to specify what tasks and resources they desire to view on-screen or in a report. The capability to generate custom reports combined with the total control that the user has over colors, symbols, patterns, bars, etc., enables the user to generate top quality output. The user can easily view schedule data in varying degrees of detail by using the expand and collapse menu buttons.

In spite of these impressive qualities, Microsoft Project depends a bit too much on its DOS roots. There are a number of areas where this occurs: it limits the user to a single window view and does not provide individual windows for the logic diagram or Gantt charts which makes the on-screen display difficult to decipher; it oddly requires the user to enter labor rates on a dollars per hour (i.e. $30/h) basis; and, it requires the user to enter full path names to subproject files in order to link the subprojects together. In addition, the calendar will not accommodate a fiscal year and the software will not support non-uniform, part time, resource scheduling. Microsoft Project also has a constricting capacity limitation of 2000 activities per project[12] which significantly decreases its capability to handle a complex project.

[12] This capacity limitation decreases to 1000 activities when operating on a Macintosh with 1 megabyte of RAM.

3.3 Recommendations

As mentioned in Section 2.2, when the criteria matrix was initially developed, it was reviewed with the customer in order to determine the relative importance of each matrix item. We considered all of the criteria in our evaluation; however, to develop the final recommendation we relied heavily on the customer's relative importance ranking. The criteria that received the highest ranking by the customer are:

- Number of Activities per Project
- Flexibility of Importing and Exporting
- User Interface
- Overall Performance and Reliability

To support a complex program such as NLS , the scheduling and project management software must be inherently flexible. While flexibility surfaces in a number of areas, one of the most crucial is activity capacity. The activity capacities of Microsoft Project, Project Scheduler 4, and ARTEMIS Schedule Publisher, do not provide significant flexibility for project growth. On the other hand, the 10,000 activity capacity of Micro-Planner X-pert and Open Plan/Mac allows the user greater flexibility to manage significantly larger projects.

The importing and exporting feature is another area that requires flexibility (see Figure 3.3 for the import and export file format options). Since Open Plan/Mac runs with a data base program, it has the greatest amount of importing and exporting flexibility of all the packages reviewed; however, the actual importing and exporting of data is difficult. PS4 and Microsoft Project offer a variety of import and export file formats; however, in the versions that we reviewed, they were not fully functional. As a result, these packages did not score favorably. Micro Planner X-pert and ARTEMIS Schedule Publisher offer a wide variety of import and export file options as well as automatic data exchange features.

User interface was constantly evaluated during the review because it encompasses several areas which include, but are not limited to, help screens, menus, tutorial, manuals, ease of use, etc. As discussed in Section 3.1, Project Scheduler 4 and Microsoft Project do not provide the user with a typical Macintosh environment. ARTEMIS Schedule Publisher provides a friendly working environment when the user is creating a schedule, but non-intuitive menus may confuse the user outside of this realm. Open Plan/Mac fails to be "user-friendly" in any area. In terms of overall user interface, Micro Planner X-pert was the strongest package.

Overall performance and reliability were almost impossible to assess because of the time constraints of the study and limited exposure to the software. The only aspect of this criteria that we were able to address was processing speed. All packages performed essentially the same except for Open Plan which was annoyingly slow.

In summary, Microsoft Project and Project Scheduler 4 have limited capacity and do not provide the user with a typical Macintosh environment. ARTEMIS Schedule Publisher does not consistently provide a user friendly environment nor does it provide as much flexibility, in terms of capacity, as Micro Planner X-pert and Open Plan/Mac. Open Plan/Mac is a very powerful software package but its complexity and nearly nonexistent user interface make it a poor choice.

Micro Planner X-pert continually demonstrated above average ratings. It is flexible and easy to use. Being the most balanced package that we reviewed, we recommend it to support the project management requirements of the NLS program.

APPENDIX A

SOURCES USED IN THE EVALUATION

Software and Documentation for:

- Project Scheduler 4/Project Scheduler 5
- Micro Planner X-pert
- ARTEMIS Schedule Publisher
- Microsoft Project
- Open Plan/Mac and Fox Base
- MacProject II
- FastTrack Schedule

Interviews with Technical Support Personnel from:

- Scitor Corporation
- Microsoft Corporation
- Welcom Software Technology Inc.
- Lucas Management Systems
- Micro Planning International
- Project Management Professionals from various local corporations

Other Sources:

Bitz, Ira. Tips and Techniques: Project Scheduler 5. September, 1991.

Heck, Mike. "Keeping Jobs On Course." Macworld, April, 1992, pp 146-151.

Heck, Mike. "Microsoft Project." Macworld, November, 1991, pp 210-211.

Heck, Mike. "The Critical Path." Infoworld, 26 November, 1990.

Heid, Jim. "Getting Started with Project Management." Macworld, March 1991, pp 211-216.

Rasmus, Daniel W. "Microsoft Project." Macuser, January 1992, pp 73-75.

Rasmus, Daniel. "Project Scheduler 4."

Rasmus, Daniel. "Project Scheduling Tools." Macuser, June 1991, pp 80-81.

1.2.8 Master Schedule Development

USBI began the master schedule task during the first quarter of 1992 and continued through December 5, 1992. This task was multifaceted with products that evolved from, and changed with, the program. Over one-hundred schedule options were generated in the following categories.

1. NLS Schedules for the PoP 92-1 Submission
2. Interim Review Development Schedules distributed May 1,1992
3. NLS Red/Blue Team Schedules (early June)
4. Space Exploration Initiative Schedules (June)
5. Michoud Production Analysis Charts/Schedules (June/July)
6. Schedules representing numerous iterations of NLS2, NLS3, and SEI launch dates
7. HLLV Schedules (August/September)
8. Transition Schedules from NLS to EHLLV (Sept/Oct)

Task report 1.2.8 is an example of the work performed under this task. It is a development schedule that was distributed on May 1, 1992.

FOLDOUT FRAME 1.

FOLDOUT FRAME 2.

NATIONAL LAUNCH SYSTEM

INTERIM REVISED DEVELOPMENT SCHEDULE (NLS 1 and 2 OPTIONS)

Attachment 2

Activities

Fiscal Year 1992 | Fiscal Year 1993 | Fiscal Year 1994 | Fiscal Year 1995 | Fiscal Year 1996 | Fiscal Year 1997 | Fiscal Year 1998 | Fiscal Year 1999 | Fiscal Year 2000 | Fiscal Year 2001 | Fiscal Year 2002 | Fiscal Year 2003 | Fiscal Year 2004

- STME Procurement — ATP
- STME Block I Engine & Component H/W — PRR, PDR, CDR
- AETF Facility Mods
- STME Block I Engine & Component Testing — AETF TEST
- STME Block II Engine & Component H/W — PRR, PDR, CDR
- STME Block II Engine & H/W Testing
- MPT Engine H/W (Blk I Reconfig) — Begin MPT
- MPT Processing & Testing
- Flight Engine H/W — Deliver 1st Flt Set (6 Engines)
- Flight Engine Testing & Delivery — 1st Flight

Zone 1 STME

- Core Vehicle Procurement — NSC Recommendation, ATP, CDR
- Core Vehicle System Design & Egr — PRR, PDR, CDR
- Core Vehicle Long Lead Procurement
- Core Vehicle Facility Mods
- Tooling
- Main Propulsion Test Article (Core Vehicle) — Receive Engines for Installation
- Common Core STA
- Struc. Static Load Tower Refurb.
- Structure Static Test
- Cryo Struct. Test Facility Mods
- Cryo Structure Test
- Vehicle Avionics Simulation Lab Facility Modification
- Vehicle Avionics Sim Lab Test
- Electromechanical Actuator (EMA) Facility Modification
- Electromechanical Actuator Test
- Prop Module Separation Test (location TBD)
- Core Structural Test & Model Survey
- Ground Vibration Test Article
- MVG Vehicle Facility Mods
- MVGVT
- KSC Pathfinder

Zone 2 Core Vehicle

- 1st Flight Article (Includes Launch Preparation) — Engine Need Date; Deliver to KSC NLS1 OPTION 1 ILC; Deliver to KSC NLS2 OPTION 2 ILC
- Acoustic Model Test (T.S. 116)
- Wind Tunnel Tests (Off site)
- Ascent Acro
- Base Heating
- On-pad Winds
- KSC FACILITIES
- Pad A or B Mods — Start Egr Activity; Start Mods, Activation, Pathfinder Need Date
- VAB (HB - 1 or 3) Mods — Start Egr Activity; Start HB Mods, Activation, Pathfinder Need Date
- Mobile Launcher Tower — Start Egr Activity; Start Construction, Activation, Pathfinder Need Date
- Operations Support Bldg IV — Start Egr Activity; Start Construction

KSC CV Related

- CTV Procurement — ATP
- CTV Design & Devt — PRR, PDR, CDR
- CTV Hardware & Test — Del Devt Comp, Prop Comp. Available, Avionics Comp. Available, Deliver CTV, ILC
- CTV Propulsion Test (White Sands or AEDC)
- CTV Structural Test (location TBD)

Zone 3 CTV

- Shroud Procurement — ATP
- Shroud Design & Devt — PRR, PDR, CDR
- Shroud Hardware & Test — Del P/L Carrier TO KSC, ILC
- Shroud Separation Test (location TBD)
- Payload Carrier Structural Test (location TBD)
- KSC Facilities
- P/L Encapsulation Facility — Start Egr Activity; Start Construction; Activation, Pathfinder Need Date
- CTV Checkout Facility — Start Egr Activity; Start Construction; Activation

Zone 4 Shroud

KSC Payload Related

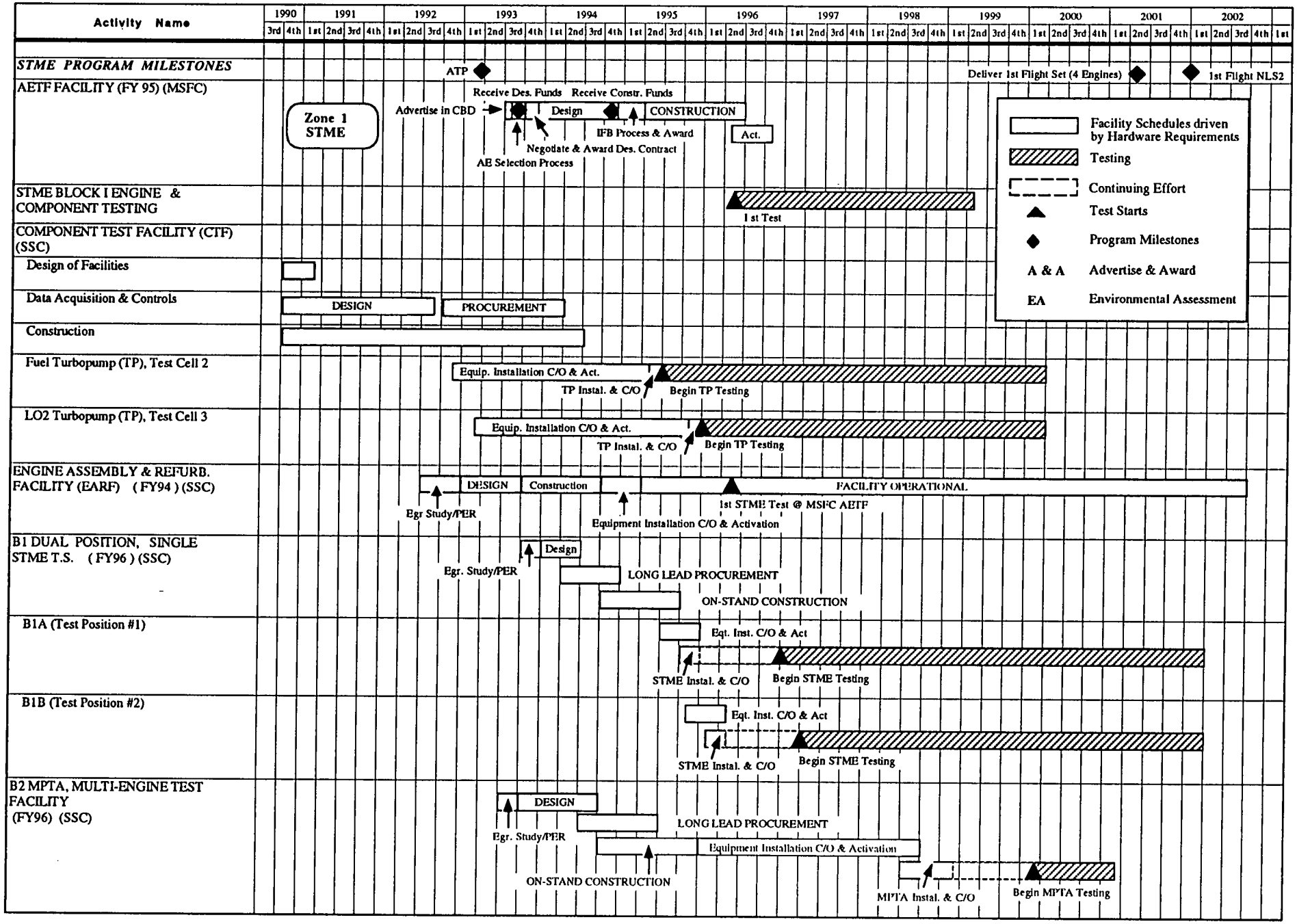
LEGEND

- Pre-Hardware
- Hardware
- Facility Mods
- Testing
- Program Milestones
- Test Milestones
- Flight Unit Delivery

1.2.9 Facilities Schedule Development

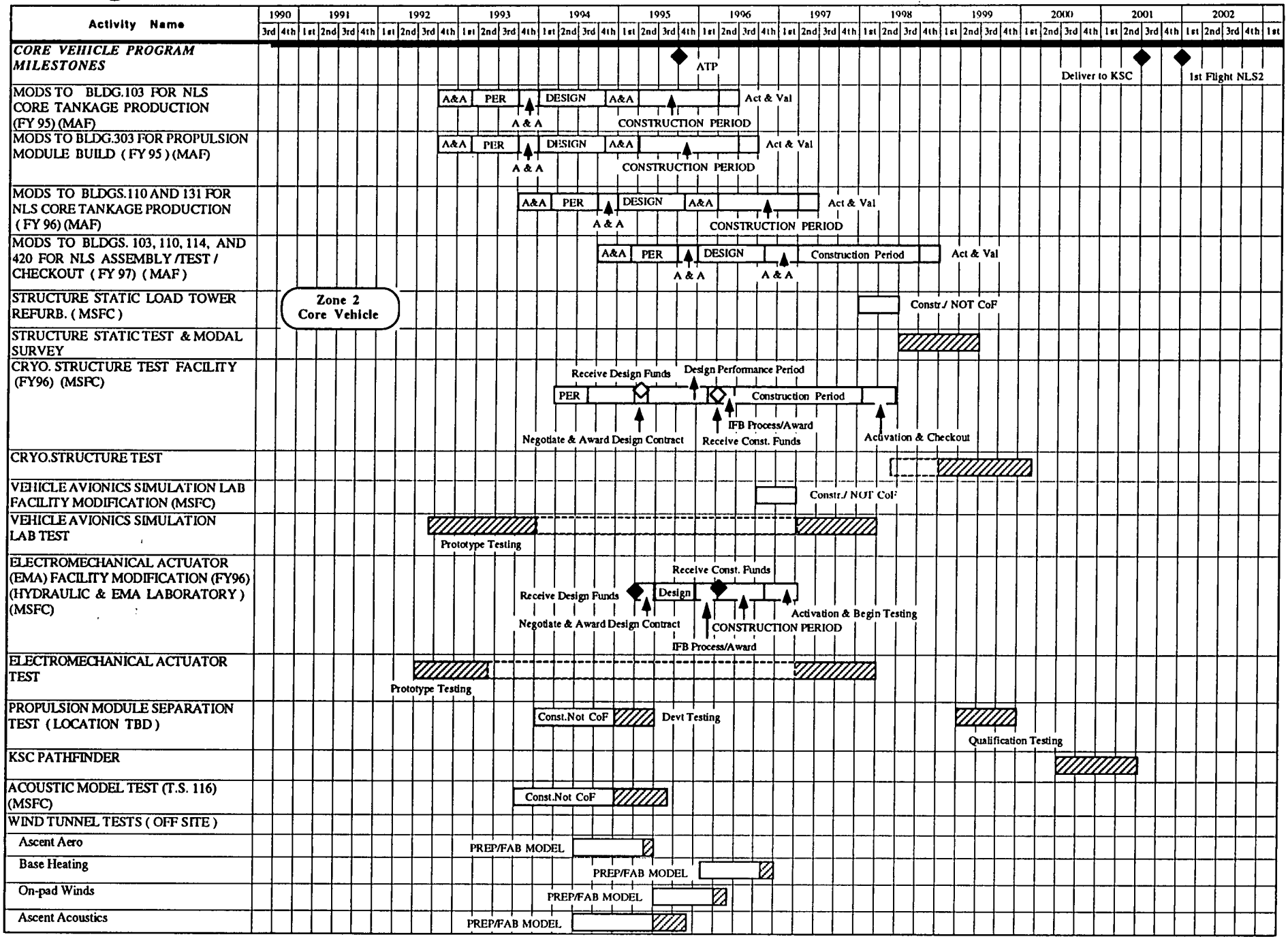
Task report 1.2.9 is an NLS Facility and Test schedule that was distributed on July 8, 1992. The development of the facility schedule was performed concurrently with the master schedule task and the development of an NLS logic network.

NLS FACILITY AND TEST SCHEDULE



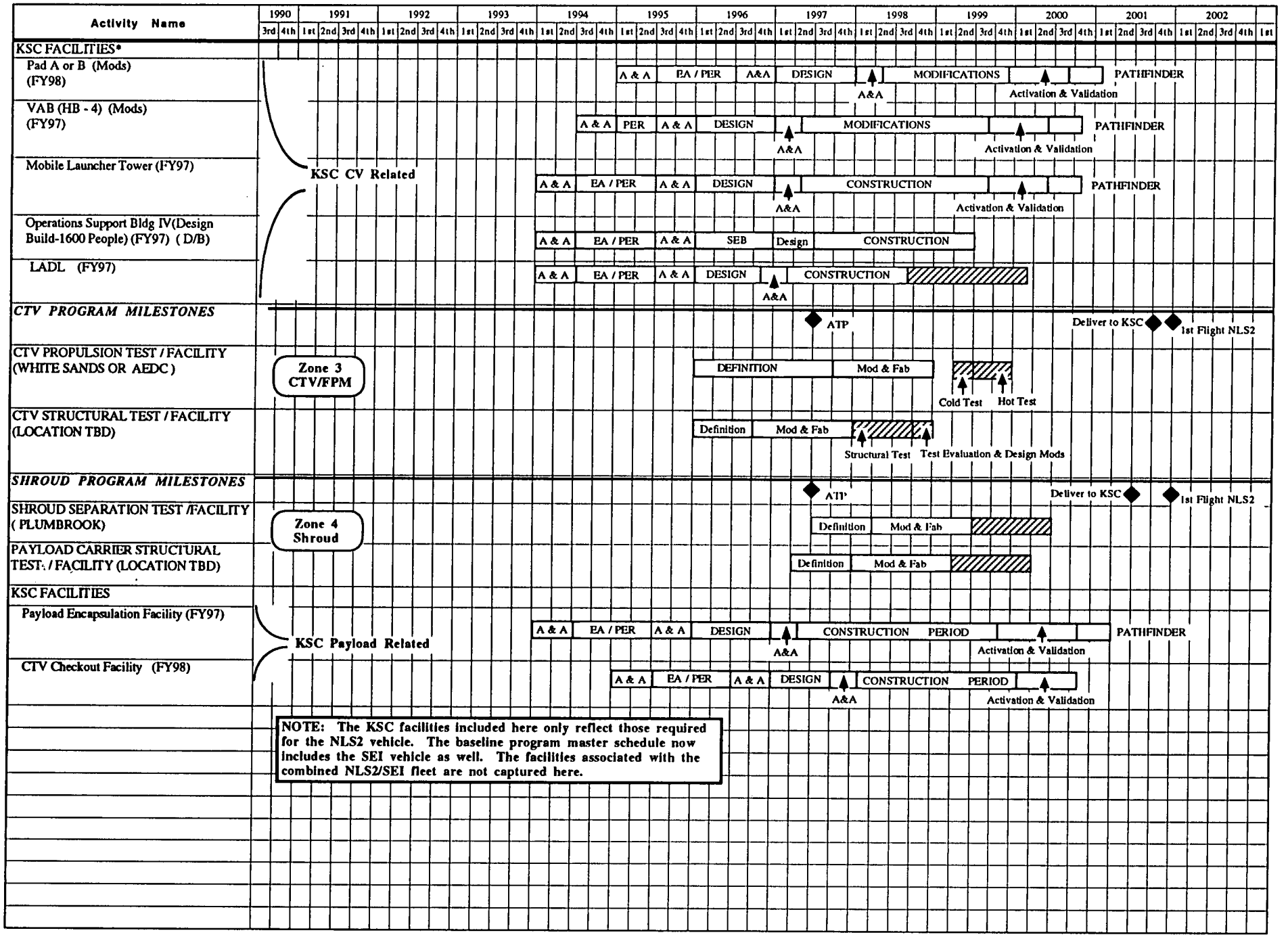
Nov 18, 1992

NLS FACILITY AND TEST SCHEDULE



Nov 18, 1992

NLS FACILITY AND TEST SCHEDULE



Nov 18, 1992

1.2.10 Logic Network Development

USBI began developing the logic network when the software evaluation was complete and continued the task concurrently with the master schedule development. Task report 1.2.10 is the NLS1 version of the network which was distributed on May 1, 1992.

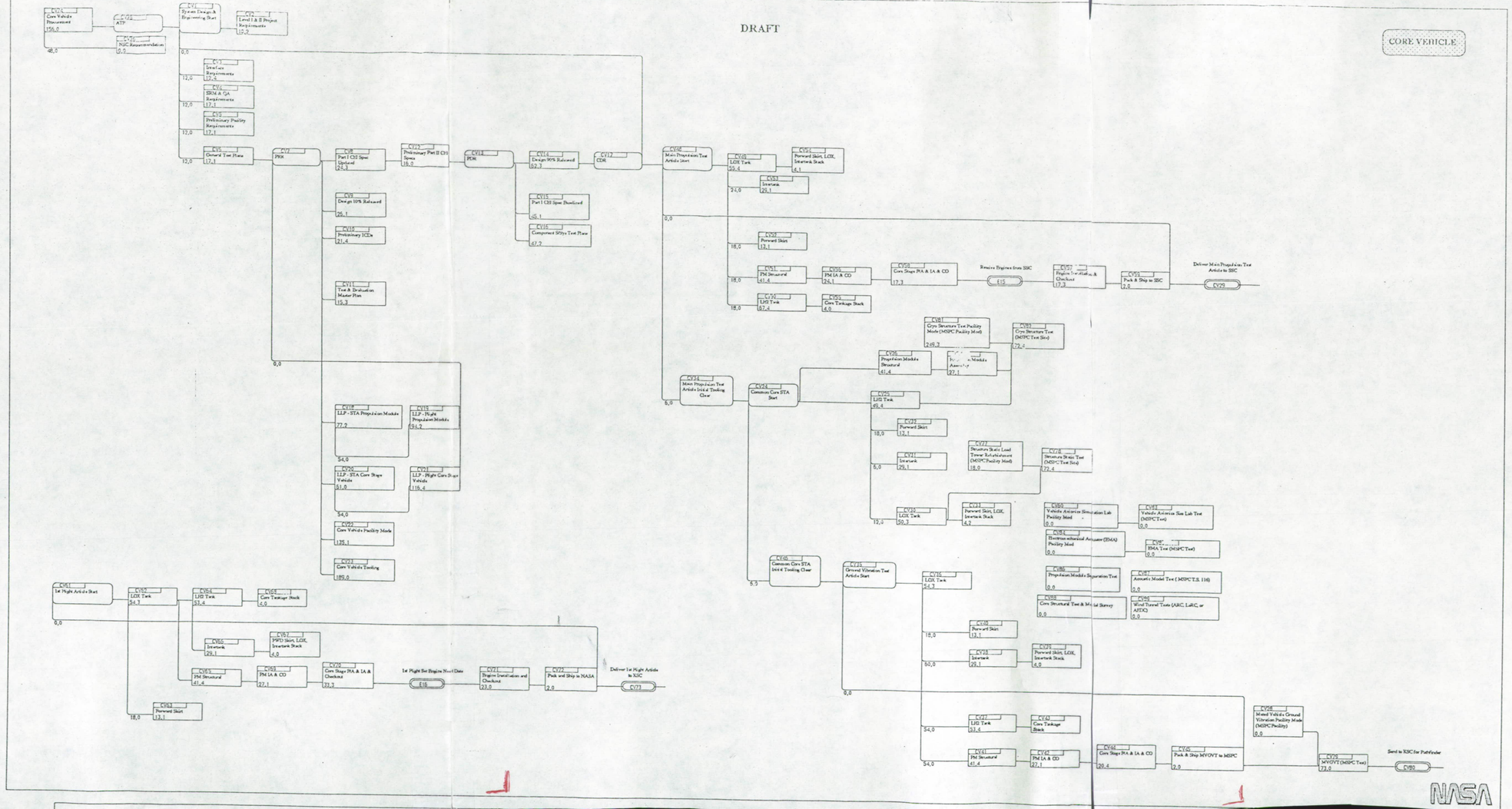
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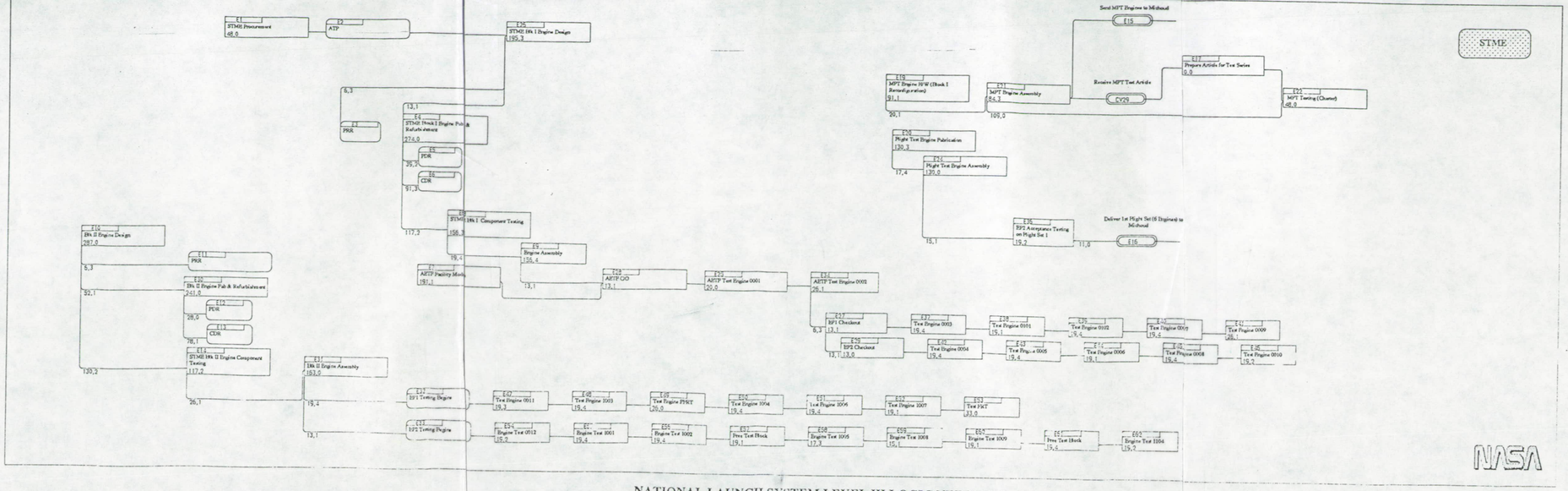
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NATIONAL LAUNCH SYSTEM LEVEL III LOGIC NETWORK
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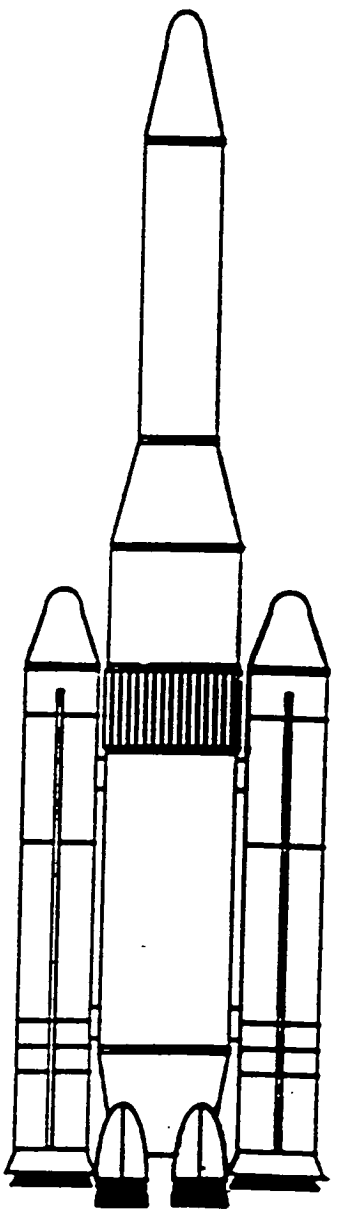
1.2.11 Project Plan

Task report 1.2.11 is a draft version of an NLS Project Plan, which describes the plan for implementation of the National Launch System (NLS) project. USBI led the coordination of this document, receiving comments from MSFC and other contractors, and integrating those comments to produce a complete document. Prepared in accordance with applicable NASA management instructions and directives, the plan covers the technical, management, and procurement approaches, as well as schedules, resource requirements, levels of control, safety, reliability, maintainability, and quality assurance aspects of the project.

NATIONAL LAUNCH SYSTEM

PROJECT PLAN

May 5, 1992



MARSHALL SPACE FLIGHT CENTER

Foreword

This project plan describes the plans for implementation of the National Launch System (NLS) Projects. The plan has been prepared in accordance with applicable NASA management instructions and directives. It covers the technical, management, and procurement approaches, as well as schedules, resource requirements, reviews, levels of control, and safety, reliability, maintainability and quality assurance aspects of the project.

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ACRONYMS

ADP	Advanced Development Program
AFSPACECOM	AirForce Space Command
ALS	Advanced Launch System
ALSYM	Advanced Launch System Model
ASE	Airborne Support Equipment
ASRM	Advanced Solid Rocket Motor
CCB	Configuration Control Board
CDR	Critical Design Review
CFD	Computional Fluid Dynamics
CIL	Critical Items List
DCR	Design Critical Review
DoD	Department of Defense
ELV	Expendable Launch Vehicle
ESMC	Eastern Space and Missle Center
FMEA	Failure Mode and Effects Analysis
FRR	Flight Readiness Review
GEO	Geosynchronous Earth Orbit
GN&C	Guidance, Navigation, and Control
GSE	Ground Support Equipment
HLLV	Heavy Lift Launch Vehicle
ICD	Interface Control Document
Isp	Specific Impulse
JSC	Johnson Space Center
KSC	Kennedy Space Center
LEO	Low Earth Orbit
MM	Management Manual
MMI	Marshall Management Instruction
MOU	Memorandum of Understanding
MSFC	Marshall Space Flight Center
NASA	National Aeronautics & Space Administration
NHB	NASA Handbook
NLS	National Launch System
NOA	

PCH	Program Critical Hardware
PDR	Preliminary Design Review
PIP	Payload Integration Plan
POP	Program Operationg Plan
PRR	Preliminary Requirements Review
RCS	Reaction Control System
RMPP	Risk Management Program Plan
SDR	System Design Requirements
S&E	Science and Engineering Directorate at MSFC
SEI	Space Exploration Initiative
S&MA	Safety and Mission Assurance
SON	Statement of Operational Need
SORD	System Operational Requirements Document
STS	Space Transportation System
TEMP	Test and Evaluation Master Plan
TPS	Thermal Protection System
USAF	United States Air Force
WBS	Work Breakdown Structure
WSMC	Western Space and Missle Center

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1. Introduction and Background

The National Space Council directed that the Department of Defense (DoD) and the National Aeronautic and Space Administration (NASA) jointly fund and develop a new space launch system to meet the civil and national defense needs, and will also actively consider commercial space needs.

The Vice President's "Advisory Committee on the Future of the U.S. Space Program" headed by Dr. Norman Augustine recommended the development of heavy lift launch capability as the next step in the nation's space future. The committee's recommendations were centered on the need to reduce dependency on the Space Transportation System (STS), lower operations costs, and provide a method to aid support of the Space Station. The committee further recommended that this system should take an evolutionary development approach to accomplish these goals both to hold down the initial development costs and provide a growth capability for future expanded space missions such as the Space Exploration Initiative.

These activities culminated in a 2 January 1991 meeting between the Deputy Secretary of Defense, the NASA Administrator, the Director of the Office of Management and Budget, and the Vice President. The Vice President requested the Department of Defense and the National Aeronautics and Space Administration to submit a joint plan to develop a system that would 1) provide a range of capabilities including heavy lift, 2) provide a man-ratable capability for some applications, 3) provide for both a near-term capability that is evolutionary and a longer term capability that incorporates new technology, 4) achieves significant improvements in operations costs (particularly launch support manpower) and- operational resilience compared to existing systems. This direction from the Vice President responds to the requirements that have been developing for many years.

The National Launch System (NLS) is the product of this direction as a joint program by NASA and the United States Air Force (USAF) and will provide for the nation's launch needs well into the 21st century. The NLS is designed to be a family of launch vehicles capable of economical operations over a wide range of payload weights. The family will utilize a modular concept and utilize common elements in different configurations.

The goals of the program are to greatly improve the national launch capability while reducing operation costs, and improving reliability, responsiveness and mission performance. The program will support a range of medium to heavy lift performance requirements and facilitate evolutionary changes as requirements evolve. The program plans take advantage of existing components to expedite initial capability and reduce development costs. It will be initially unmanned but designed to be man-rateable.

2. Project Plan Summary

This document describes the overall objectives of the National Launch System and overall plan for its development and operation. The NLS will be developed under the cognizance of NASA Code MD and the U.S. Air Force Space Division. Five NASA Centers are involved in the project with Marshall Space Flight Center serving as the lead center responsible for overall project management. Kennedy Space Center is responsible for the operations development. Langley Research Center provides leadership for the avionics area and the structures area of the Advanced Development Program. Stennis Space Center will provide engine test capability, with Johnson Space Center providing expertise on flight operations.

The NLS is planned to provide launch capability to meet the nations needs, both military and civil, well into the 21st century. It is envisioned to be lower cost, more reliable, and more robust than any program before it.

The program marks its beginning in 1986. The cost of the development program in real year dollars will be 11.487 billion (FY-91$) through first launch. First launch is scheduled for 2002. A substantial portion of the definition and development will be accomplished by civil service personnel, while most of the detail design, fabrication, assembly, and test will be accomplished by contractors. The civil service manpower is estimated to be xxx man-years of effort through first launch.

The NLS will be a multi-mission, multi-vehicle project. The project will provide the launch vehicles, the payload shrouds, and the payload accommodation system. The different vehicles, configurations are capable of economically launching to Low Earth Orbit (LEO) a range of payloads of as little as 20 Klbs and as much as 360 Klbs. With the exception of the Space Transportation Main Engine (STME), there are no major technological developments or advancements to the state-of-the-art required for implementation of the NLS Project.

Preliminary assessment of the environmental impact has identified no widespread or long-term deleterious effects on the natural environments.

3. Project and Mission Objectives

a. Project Objectives

The National Space Council has established specific NLS objectives, namely:

- a range of payload capabilities, including heavy-lift,
- a man-rateable capability for some applications,
- an evolutionary near-term capability plus a longer-term capability incorporating new technology, and
- significant improvements in operations cost and operational resiliency.

The NLS is well founded, having evolved from extensive requirements analyses, concept study and technology development activities conducted with broad industry participation since 1985 under joint DoD/NASA management (Space Transportation Architecture, Advanced Launch System Program, and the Advanced Launch Development Program) or under NASA Marshall Space Flight Center (MSFC) management (Shuttle-C Program). These activities have investigated and identified system design, development, production, and operational concepts for achieving substantially improved reliability, operability, and economy over current systems for space mission needs encompassing a wide range of payload sizes and orbital destinations. These NLS concepts also will provide vehicle and infrastructure capabilities for improved United States competitiveness in commercial space launch.

Based upon the results of prior concept studies, the NLS will:

- be comprised of a family of modular vehicle,
- implement an Integrate-Transfer-Launch (ITL) operations concept,
- have launch processes, facilities and processing equipment designed and constructed to minimize operations and manpower requirements,
- have a LOX/LH2 Space Transportation Main Engine (STME) designed and built as a low cost, highly reliable propulsion system,
- be designed with robust systems and subsystems margins,
- provide flexibility in infrastructure to support contingencies as well as routine missions,
- emphasize cost and reliability, not purely performance,
- utilize existing and new technologies as required to meet the above objectives and cost goals, and
- employ a fully integrated information system to support the entire NLS life cycle from design and development through vehicle checkout and launch, and to enhance operability and economy.

The prior system concept activities have also shown the importance of utilizing a new total quality approach to acquisitions and operations. The NLS Program will be characterized by a continual emphasis on understanding and meeting NLS customers' needs and requirements, an acquisition approach that fosters teamwork between government and industry, and by efficient operations. Total Quality Management (TQM) goals and NLS program objectives are completely aligned. A dedication to quality, responsiveness and economy is the underlying tenet of the program.

NLS launch capabilities will first be implemented at NASA/Kennedy Space Center (KSC) (using the Shuttle Vertical Assembly Building (VAB) and Launch Complex 39). Next, NLS will be implemented at Cape Canaveral Air Force Station (CCAFS) with a single launch pad and processing facilities compatible with the ITL concept. NLS expansion planning envisions additional launch capabilities at Vandenberg Air Force Base (VAFB). Initially, the NLS will share the total launch traffic demand with Titan IV, other contemporary expendable launch vehicles, and the Space Shuttle, while providing increased lift capability and lower unit costs.

b. Mission Objectives

To accomplish its present baseline missions, the NLS shall include a modular family of vehicle configurations. To meet overall system objectives, each vehicle configuration shall have as much communality with other NLS vehicles as is practical, and shall use the STME. The NLS shall provide the vehicle configurations and capabilities identified in the following paragraphs.

The NLS design shall be capable of accommodating diverse payloads (e.g., a range of c.g. locations), and shall minimize sensitivity to specific cargo characteristics, given that payloads are designed commensurate with the NLS Payload Planning Handbook guidelines.

The NLS Vehicle Family

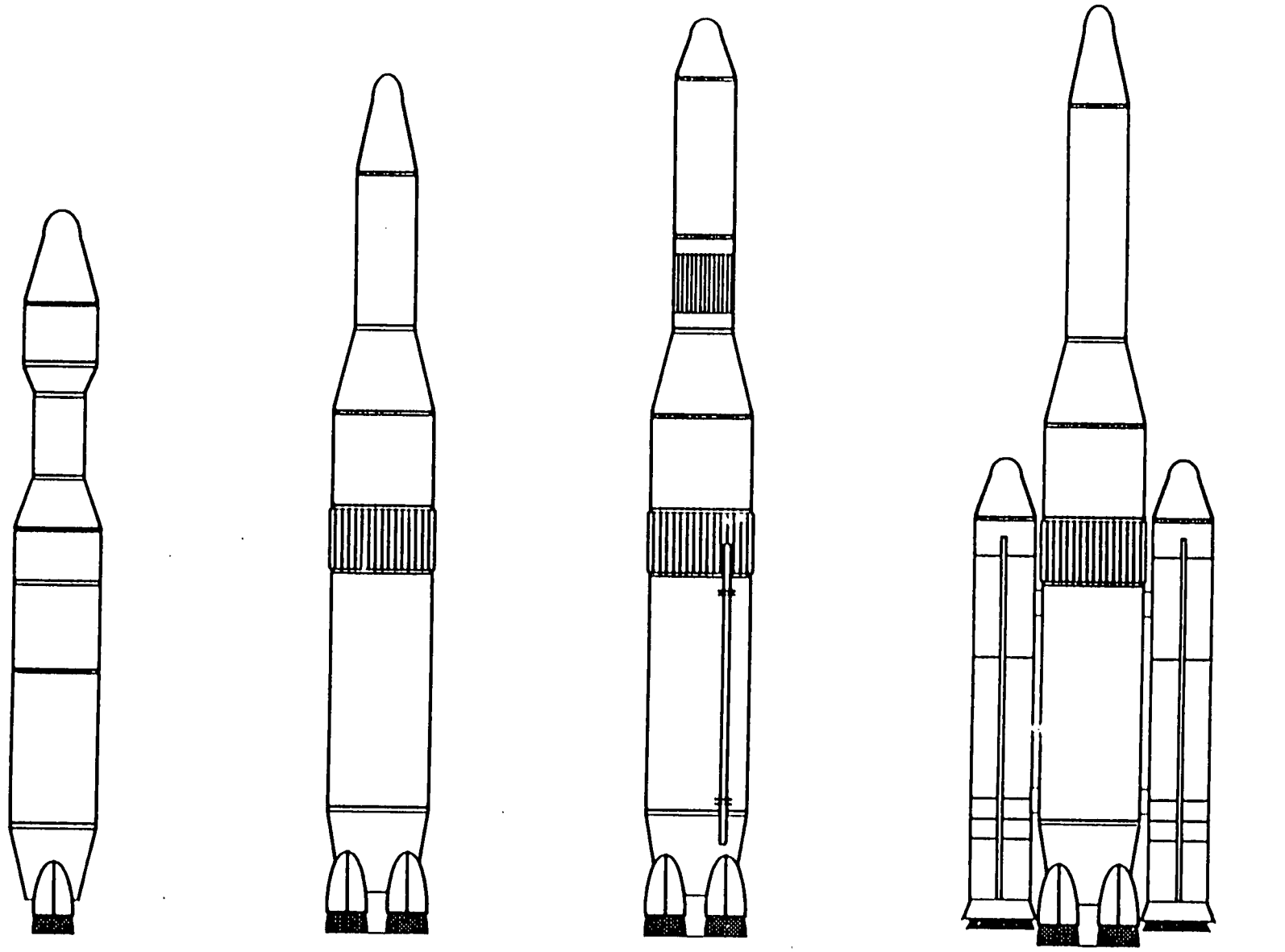


Figure 3-1.

NLS Launch Weight Goals

NLS Vehicle Configuration	Orbit						
	Launches from KSC or CCAFS						
	80 x 150 n. mi.		98.7°	220 n.mi. 28.5°	GEO 0°	GTO	Earth Escape
	28.5°	57°					
20 Klbs	(20,000)	X			(3,500)	8,000	
1.5 Stage	(50,000)	X					
2.5 Stage	80,000	X	X	X	(15,000)	X	X
HLLV	X	X		(80,000)			

NLS Vehicle Configuration	Orbit		
	Launches from VAFB		
	80 x 150 n. mi.		
	70°	90°	98.7°
20 Klbs	X	(20,000)	X
1.5 Stage	X	(50,000)	X
2.5 Stage	X	80,000	X

Key
1,000 = Potential Weight Capacity
(1,000) = Requirement Weight Capacity
X = TBD

Figure 3-2.

Orbital Delivery Accuracy Requirements

Delivery Orbit Parameter	220 n.mi. Delivery Accuracy	80 x 150 n.mi. Delivery Acccuracy	GEO Delivery Accuracy
Apogee	TBD	+/-10 n.mi.	
Perigee	TBD	+10 n.mi., -2 n.mi.	
Inclination	TBD	+/-0.25 deg.	+/-0.08 deg.
Eccentricity			0.003 maximum
Drift Rate			+/-0.5 deg./day
Ascending Node Longitude at Equator	TBD	TBD	TBD

Figure 3-3.

4. Summary of Technical Plan

a. Missions

The nominal traffic model estimates 33 launches during the first seven years of operation, beginning in FY 2002. These include: 14 flights of the 1.5 Stage NASA application, 7 flights in the HLLV NASA configuration, 11 flights in the 2.5 Stage DoD, and 1 flight in the 1.5 Stage DoD (20Klbs) configuration.

The system shall be designed to support a minimum of 10 flights per year plus a launch rate margin of 35 percent (total 13.5 flights per year) to accommodate the need for resiliency. The NLS shall also have production and launch rate capacity at CCAFS to accommodate 10 flights per year with increases to 25 by modular addition to flight facilities. This increased flight rate capacity may be used for the elimination of cargo backlog in the event of a major system failure, or to obtain system dependability or provide operational flexibility.

b. Vehicle Configurations and Performance

The specific rated lift capabilities of each NLS family member or combination thereof shall be in accordance with the System Requirements Document (SRD). While NLS is to embrace a family of vehicle configuration with capabilities over a wide range of payloads, Figure 3.1 depicts four reference configurations, and Figure 3.2 and 3.3 provide performance characteristics.

c. Payload Volume per Launch

For applications using the various vehicle configurations, payload shrouds shall be capable of accommodating a STS-compatible

cargo carrier or a STS Dual Class Payload, a payload or payload/NLSUS combination defined by a cylinder 15 feet in diameter and 60 feet in length, and a payload defined by a cylinder 13 feet in diameter and 25 feet in length.

d. Technology Plan

A focused technology development program is an integral part of the NLS to show proof of concept and to demonstrate the overall cost, operability and performance goals of the system and a method for improving current systems.

e. Program Risks

A risk assessment program will be developed to review the technological, schedule, and cost risks associated with each Program. The risk assessments will be used to develop and implement mitigation or avoidance.

f. Analysis of Environmental Impact

Proper analyses will be conducted to accurately assess the impact of facilities, materials usage, manufacturing techniques, transportation services, assembly operations, and launches on the surrounding environment to ensure that no detrimental impact has been perpetrated. Any variances in the allowable environmental impact will be addressed to insure compliance with all federal, state and local ordinances.

g. Logistics

The NLS logistics activities will be integrated with other disciplines and functions to assure cost effective support for the life of the project. NLS logistics planning and implementations will be tailored specifically to NLS project requirements.

Individual elements of the NLS system can be transported separately by whatever means best suit the particular segment, to the consolidated integration facility.

h. Operations

The integration and verification functions of the NLS Program will differ from most historic launch vehicles and rockets, with the incorporation of the Integrate-Transfer-Launch (ITL) process. This approach will streamline both the integration and verification due to the systematic build-up and concurrent testing of the vehicle at the launch complex.

5. Management Approach

a. General

In order to provide effective communication between the management elements of the program and to assure the timely resolution of problems, a comprehensive management plan has been established. A prime consideration is that the appropriate level of management be apprised of any problems, and that the problems be resolved with minimum impact to the program, either in cost or schedule. Figure 6-1 shows the NLS management structure.

b. Headquarters Responsibilities (Level 0)

i. Joint Space Launch Acquisition Board (J-SLAB)

A joint DoD and NASA Space Launch Acquisition Board is established to provide the primary forum for resolving issues and facilitating decisions for the NLS Program. The Under Secretary of Defense, Acquisition, and the NASA Deputy Administrator will co-chair the J-SLAB. J-SLAB responsibilities include:

Providing program policy guidance,

The HLLV Definition Office will plan and direct those portions of the NASA activities assigned to MSFC including the Launch Vehicle design, the Space Transportation Main Engine (STME), the Cargo Transfer Vehicle (CTV), related systems, and test activities. It will manage MSFC and industry performance in planning, design, engineering, integration, development, production, testing, delivery, and operations of launch vehicle elements furnished by MSFC, assuring that cost, schedule, and performance goals are met. In accomplishing its mission, the Heavy Lift Launch Vehicle Definition Office integrates project level planning and operational activities assuring the aggregate accomplishment of MSFC assignments. Figure 6-3 shows the HLLV Definition Office management structure.

Responsibilities

Manages definition and development phases of program planning, budgeting, scheduling, engineering design and development, testing and evaluation, and cost control of the launch vehicle, STME, Payload Accommodation System (PAS), and related systems, including support equipment, facilities, and launch operations support. Exercises authority for planning and directing the NLS definition activities in a manner judged to produce the best results in terms of quality, efficiency, economy, effectiveness, and timeliness. Maintains technical and management control of programs for expedient progress in accordance with program plans and schedules.

Assures, through programmatic and technical interchanges with the Space Shuttle Projects Office, the integration of the appropriate NLS elements with external tank activities at the Michoud Assembly Facility.

Facilitates the technical interchanges along all program and project elements.

NLS Management Structure

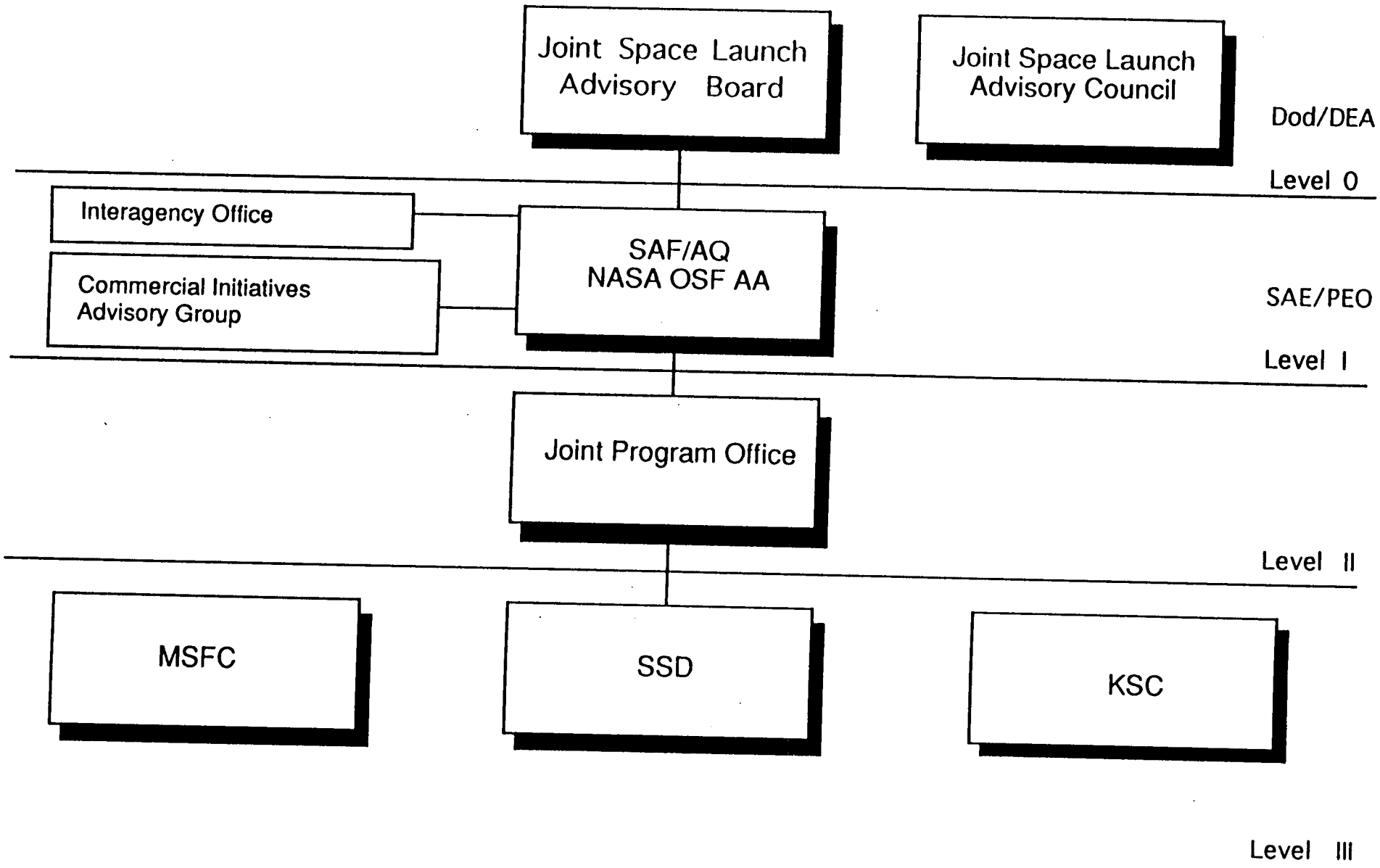


Figure 6-1

- Approving the acquisition strategy and program baseline,
- Conducting major milestone/phase reviews and,
- Resolving issues.

ii. Joint Space Launch Advisory Committee (J-SLAC)

The J-SLAB will be supported by the Joint Space Launch Advisory Committee; a joint DoD/NASA committee co-chaired by the Deputy Director Defense Research and Engineering (Strategic and Nuclear Forces) and the Deputy Associate Administrator (TBD).

c. Level I Responsibilities

Level I provides the sustaining, agency level management of the NLS Program, and this is accomplished within the Air Force by the Under Secretary of the Air Force for Acquisition (SAF/AQ) and within NASA by the Associate Administrator for (TBD).

i. Senior Acquisition Management

The Senior Acquisition Executive for the NLS Program is SAF/AQ for the Air Force, and AA/(TBD) for NASA. They will jointly review and approve the NLS program plan and budget allocations recommended by the Joint Program Office (Level II).

ii. System Control Board

The System Control Board (SCB) manages and controls the system level technical baseline for the NLS Program. The SCB is the final authority on technical issues at the requirements level. The SCB membership consists of:

NASA: - Director for (TBD)
- Director, Marshall Space Flight Center
- Director, Kennedy Space Flight Center

DoD/AF: - DAC (or PEO)

- AFSPACECOM/CC
- Add one

iii. Commercial Initiatives Advisory Group

The advisory panel provides periodic updates on NLS progress and advice on how NLS can best support the competitive needs of the commercial launch industry.

d. Joint Program Office (Level II)

This level provides the day to day management of the NLS Program. The Joint Program Office (JPO) is the organization which provides this function. The JPO is responsible for the implementation and is given the authority necessary to execute this responsibility. The JPO has an Air Force Program Director (PD) and a NASA Program Deputy. The Director reports to SAF/AQ.

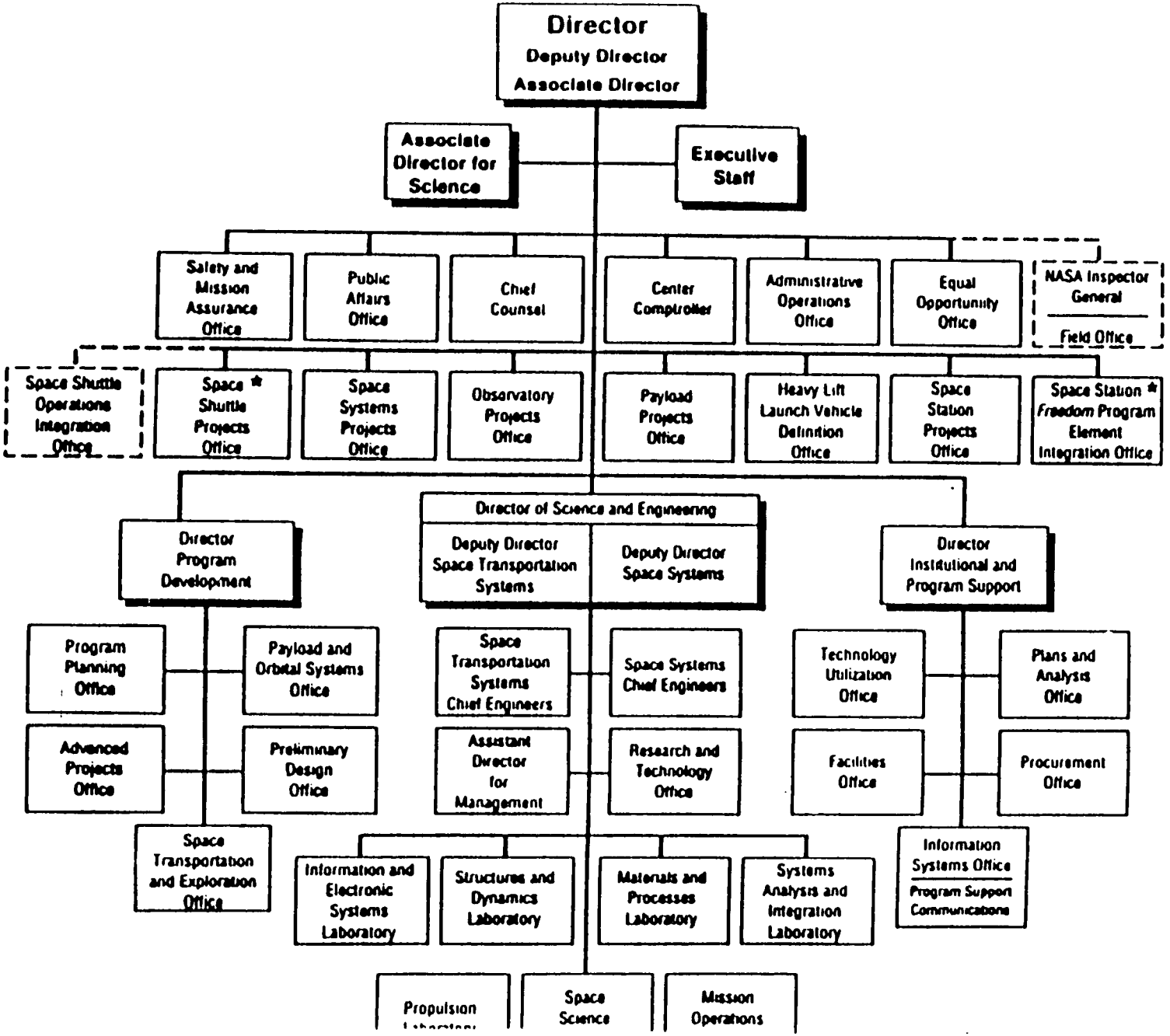
e. Center Responsibilities (Level III)

Level III is responsible for the management of specific NLS program elements. The manager of these elements reports to a Level III manager, who reports to the JPO.

The MFSC Level III responsibilities include the procurement, management, definition, design, development, and delivery of assigned vehicle system and elements; the system integration of assigned launch vehicle components; the interface definition and technical support in the development of launch processing and launch operations, and the analytical integration of the launch vehicles. Figure 6-2 shows the MSFC management structure.

Functions of the HLLV Definition Office

MSFC Management Structure



HLLV Definition Office Mangement Structure

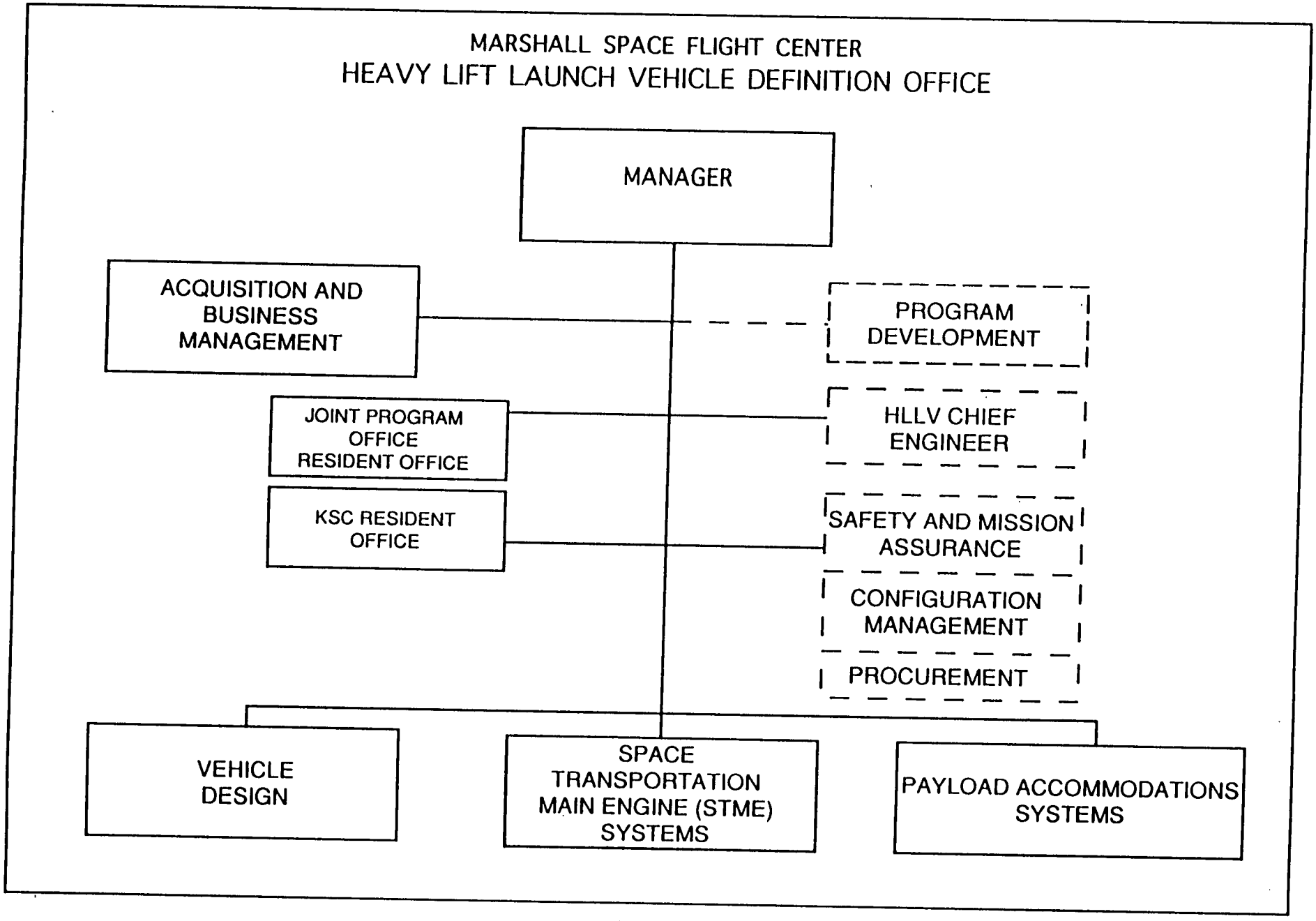


Figure 6-3.

Assures, through direction of appropriate officials, that technical requirements in planning, design, development, and test of the launch vehicles, STME, and PAS elements are met in accordance with approved schedules; that technical problems are quickly identified and resolved; and that systems are properly integrated into overall projects. Establishes priorities and directs the initiation, discontinuance, redirection, review, and approval of work and resources.

Authority

The Manager, Heavy Lift Launch Vehicle Definition Office, is authorized to take such actions as necessary to carry out the functions assigned in consonance with applicable laws, regulations, NASA and MSFC policies.

Management Relationships

The Manager, Heavy Lift Launch Vehicle Definition Office, responds functionally to the Director, National Launch System Joint Program Office, Space Systems Division, USAF. He reports to the Director, MSFC, and is responsible for assuring that the Director is kept informed on design, development, and procurement of hardware in a timely manner. The individual project managers for a launch vehicle, STME, PAS, and related technical staff offices are responsible to the Manager, NLS Projects Office.

Within the areas of responsibility delegated herein, and recognizing the responsibilities of other MSFC organizational elements, the Manager, Heavy Lift Launch Vehicle Definition Office will:

- Attend or chair conferences and technical meetings with NASA Headquarters, NASA Centers, USAF Laboratories, other appropriate DoD organizations, contractors, and MSFC organizations to

discuss advise, and establish specifications, design, and development requirements for the launch vehicle, STME, and PAS elements.

- Function as an expert technical advisor and consultant to the Director, Heavy Lift Launch Vehicle Definition Office Joint Program Office and to Agency officials in the areas of launch vehicle, STME, and PAS development, production, test, integration, and operations. Advise on the systems peculiarities, capabilities, and limitations, and specific technical details which could influence related space projects.

- Recommend courses of action, i.e., changes to design, revision of schedules, and/or budget changes, necessary due to interface problems, changes in mission, new technical developments, or other reasons.

- Participate as a senior member of Center management in the continual development of MSFC policies and review of MSFC programs.

- Serve on MSFC, NASA, and other government, industry, or community boards, panels, committees, councils, working groups, and ad hoc groups as requested or approved by the Director, MSFC.

- Utilize the management and technical capabilities vested in other MSFC elements whenever possible to achieve economy of operations commensurate with assigned responsibilities.

The Heavy Lift Launch Vehicle Definition Office Chief Engineer, formally assigned to the Space Transportation Systems Chief Engineers, Science and Engineering Directorate, will be functionally assigned to the Heavy Lift Launch Vehicle Definition Office. In addition, each project within the Heavy Lift Launch Vehicle Definition Office will be provided a project chief engineer assigned to the HLLV Definition Office Chief Engineer and each will function as a member of the project office responsible to the project manager for:

- Defining vehicle and element options that support program requirements,
- Determining the project requirements for contractor and in-house engineering activities,
- Assessing technical and programmatic impacts to support decisions involving tradeoffs and solutions to interface problems,
- Providing capability for decisions involving tradeoffs and solutions to interface problems,
- Evaluating and approving the interrelated engineering activities of the project office, S&E, and the contractor, and,
- Assuring that Science and Engineering Directorate technical commitments to the program are met.

Th NLS Projects Office Safety and Mission Assurance (S&MA) representatives, formally assigned to the Safety and Mission Assurance Office, will be functionally assigned to the NLS Projects Office and will function as member of the project office responsible to the project manager for:

- Establishing requirements, approving plans, assessing implementation, and recommending corrective actions for safety, reliability, maintainability, and quality assurance activities to be accomplished on MSFC Heavy Lift Launch Vehicle Definition Office projects,
- Conducting inspections of hardware and surveillance of in-house test operations and assuring, through resident personnel and inspection agencies, that these inspections and surveillance functions are accomplished on contracted efforts,
- Serving as the focal point for overall S&MA phases of design, manufacturing, and testing activities throughout all MSFC HLLV elements, and,

- Coordinates all formal and informal Total Quality Management (TQM) training for MSFC personnel for all MSFC HLLV elements.

The NLS configuration management representatives, formally assigned to the Configuration Management Division, Systems Analysis and Integration Laboratory, Science and Engineering Directorate, will be functionally assigned to the NLS Projects Office and will function as members of the project office responsible to the project manager for:

- Directing, monitoring, and evaluating the effectiveness of configuration management implementation and identifying required resources,
- Monitoring prime contractors compliance with configuration management contractual requirements, and,
- Serving as Level II/III Configuration Control Board Secretaries for the projects.

The NLS Projects Office procurement representatives, formally assigned to the Procurement Office, Institutional and Program Support Directorate, will be functionally assigned to the NLS Project Office and will function as members of the project office responsible to the project manager for:

- Contract planning, negotiation, and administration,
- Review and evaluation of contractor proposals for conformance to established policies, guidelines, and procedures and to assure adequacy,
- Assures that all procurement actions are in compliance with law, implementing instructions, policy, and sound business practices, and,
- Provides support for source selection processes, as required, and for the Performance Evaluation Boards for cost-plus-award-fee contracts.

The NLS Projects Office will be supported by a Concept Definition Task Manager formally assigned to the Program Development Directorate and functionally responsible to the NLS Office Chief Engineer for technical matters and to the Manager, NLS Projects Office for cost estimation and programmatic support.

Hardware Offices

The NLS Projects Office will have three branches dealing with Vehicle , STME, and the PAS. The Vehicle Office will be responsible for all activities related to the design and development of the vehicles, and will interface with other definition office management, and contractors for the activities.

The Space Transportation Main Engine Systems Office will coordinate all activities relating to the design and development of the STME systems. This office will interface with other definition office management, and engine design and development contractors.

The Payload Accommodation System Office will be responsible for all activities related to the design and development of the CTV and Payload Shrouds and will interface with other definition office management, and contractors for the activities.

f. Other Interfaces

i. Level I Program Reviews

Level 1 may call Program Reviews at major decision points or to address major program issues. The reviews will focus on issues affecting program goals, objectives or progress.

ii. Acquisition Requirements

Acquisitions of hardware and/or services will be accomplished utilizing the regulations, procedures and customs of the Agency, and will involve DoD personnel as appropriate for joint program coordination.

iii. Reporting

Administrative reporting will be accomplished through channels agreed upon between the activities furnishing resources to the NLS Program and the JPO. Formal Program reporting will normally originate at Level III and flow up to Level II. Reporting internal to MSFC will follow normal lines of institutional organization.

iv. Security and Public Release

All requests for public release of NLS information in any form (verbal, visual, printed, etc.) will be submitted through the MSFC public affairs channels in accordance with MMI (TBD), and coordinated with the JPO.

6. Procurement Strategy

a. General

The NLS Projects will implement a Total Quality Management (TQM) approach to procurement, insuring continual emphasis on understanding and meeting NLS customers' needs and requirements. For cost effective procurement, NLS will make appropriate use of existing hardware, facilities, and tooling for major structural elements, e.g., propellant tanks, intertanks, and the Advanced Solid Rocket Motor (ASRM). Additionally, the NLS vehicle family will be configured to facilitate modular growth to vehicles capable of accommodating very large payloads such as those being considered by the Strategic Defense Initiative (SDI) and the Space Exploration Initiative (SEI).

b. Make Versus Buy Plan

The NLS Projects will implement a make versus buy decision methodology plan for all planned acquisitions. The decision criteria developed for the program will be applied to each acquisition to determine the best procurement process, considering schedule, risk factors and resources.

c. Planned Acquisitions

The Marshal Space Flight Center will be responsible for three major procurements: The STME; the Vehicle; and the Payload Accommodation System.

The STME Phase C/D RFP has been released. Only one proposal is sought. The consortium known as the Space Transportation Propulsion Team (STPT) is expected to be the only proposer.

The vehicle Phase C/D RFP will include the development of the tank age, the forward skirt and thrust structure, the interface hardware, the stage physical integration (to include the STME), and the vehicle analytical integration. This award will be made to a single contractor based on full and open competition. The contract will include the development of all necessary hardware, tests, and analyses.

The Payload Accommodation System Phase C/D award will be made to a single contractor based upon full and open competition These phases will include the development of all necessary hardware, tests, and analyses.

Organizations charts for the individual Project Offices are shown in the appendices. STME - Appendix A; Vehicles - Apendix B; Pas - Appendix C.

8. Project Schedules

a. General

The NLS program Schedules consist of all the schedules from the detailed schedules of the performing organizations to the Level 0 schedules. The Level 0 schedule, Figure 8-1, shall be considered the master schedule for the program. Schedules for the individual projects are shown in the Appendices. STME - Appendix A; Vehicles - Appendix B; - Appendix C.

b. Major Project Milestones

Major project milestones are those events which are of major interest to the program and project levels of management, and are indicated on all project schedules. Changes to the scheduled dates for these events require approval of the program manager. Other milestones supporting the major milestones are also indicated on the schedule. The major milestones for the project are shown in Figure 8-1.

c. External Milestones

The key milestones external to, but interfacing with the NLS project are other launches from the same facility. These launches which would bracket the NLS launches, and those which result in placing demands on mission operations support essential to achieving NLS mission objectives, require close surveillance because of possible impact to the NLS project.

d. Procurement and Budget Schedules

There is a direct operational relationship between scheduling procurement activities and the availability of resources in the design and development phases. This relationship is more conceptual during the definition phases. Procurements scheduled herein are consistent with the resources plan in Section 9. Utilization of

contractors during any holding period is dependent upon availability of resources and any options and alternatives afforded the agency.

8. Resources Plan

Total development funds for the NLS Program through first flight are estimated to be 11.487 billion dollars (FY-91$) Resources for the individual projects are shown in the Appendices. STME - Appendix A; Vehicles - Appendix B; PAS - Appendix C.

9. Management Review

a. General

In order to provide effective communications between the management elements of the program and to assure the timely resolution of problems, a comprehensive management review procedure has been established. A prime consideration is that the appropriate level of management be apprised of any problems, and that these problems be resolved with minimum impact to the project, cost, or schedule. All levels of program and project management periodically review status as an integral part of the management function. Special reviews by any level of management are conducted when the need arises.

b. NLS Program Manager Review

The NLS Program Manager is kept apprised by frequent contact with the NLS Projects Office at MSFC and with its program participants. He may participate in the (TBD) Associate Administrators monthly reviews. In addition he periodically reviews the program with the MSFC Projects Manager.

During the regularly scheduled monthly meeting of the Associate Administrator for (TBD), the status of the projects are reviewed along with the other projects of the Office of (TBD). Items

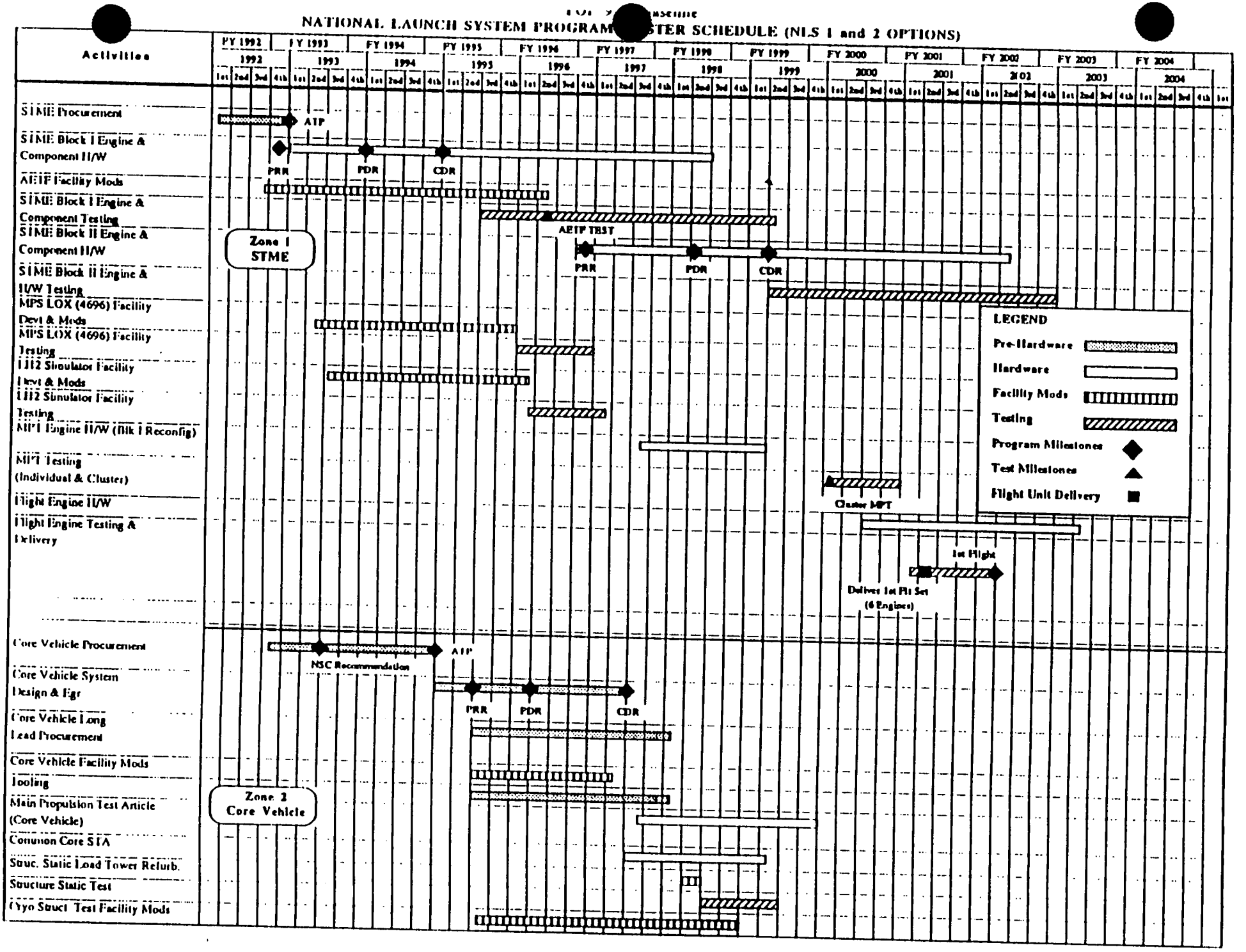

NATIONAL LAUNCH SYSTEM PROGRAM
STER SCHEDULE (NLS 1 and 2 OPTIONS)
Activities
FY 1992
FY 1993
FY 1994
FY 1995
FY 1996
FY 1997
FY 1998
FY 1999
FY 2000
FY 2001
FY 2002
FY 2003
FY 2004
SIME Procurement
ATP
SIME Block I Engine & Component H/W
PRR
PDR
CDR
AETF Facility Mods
SIME Block I Engine & Component Testing
AETF TEST
Zone 1 STME
SIME Block II Engine & Component H/W
SIME Block II Engine & H/W Testing
MPS LOX (4696) Facility Devt & Mods
MPS LOX (4696) Facility Testing
LH2 Simulator Facility Devt & Mods
LH2 Simulator Facility Testing
MPT Engine H/W (Blk I Reconfig)
MPT Testing (Individual & Cluster)
Cluster MPT
Flight Engine H/W
Flight Engine Testing & Delivery
1st Flight
Deliver 1st Flt Set (6 Engines)
LEGEND
Pre-Hardware
Hardware
Facility Mods
Testing
Program Milestones
Test Milestones
Flight Unit Delivery
Core Vehicle Procurement
NSC Recommendation
ATP
Core Vehicle System Design & Egr
PRR
PDR
CDR
Core Vehicle Long Lead Procurement
Core Vehicle Facility Mods
Tooling
Zone 2 Core Vehicle
Main Propulsion Test Article (Core Vehicle)
Common Core STA
Struc. Static Load Tower Refurb.
Structure Static Test
Cryo Struct Test Facility Mods

Figure 8-1

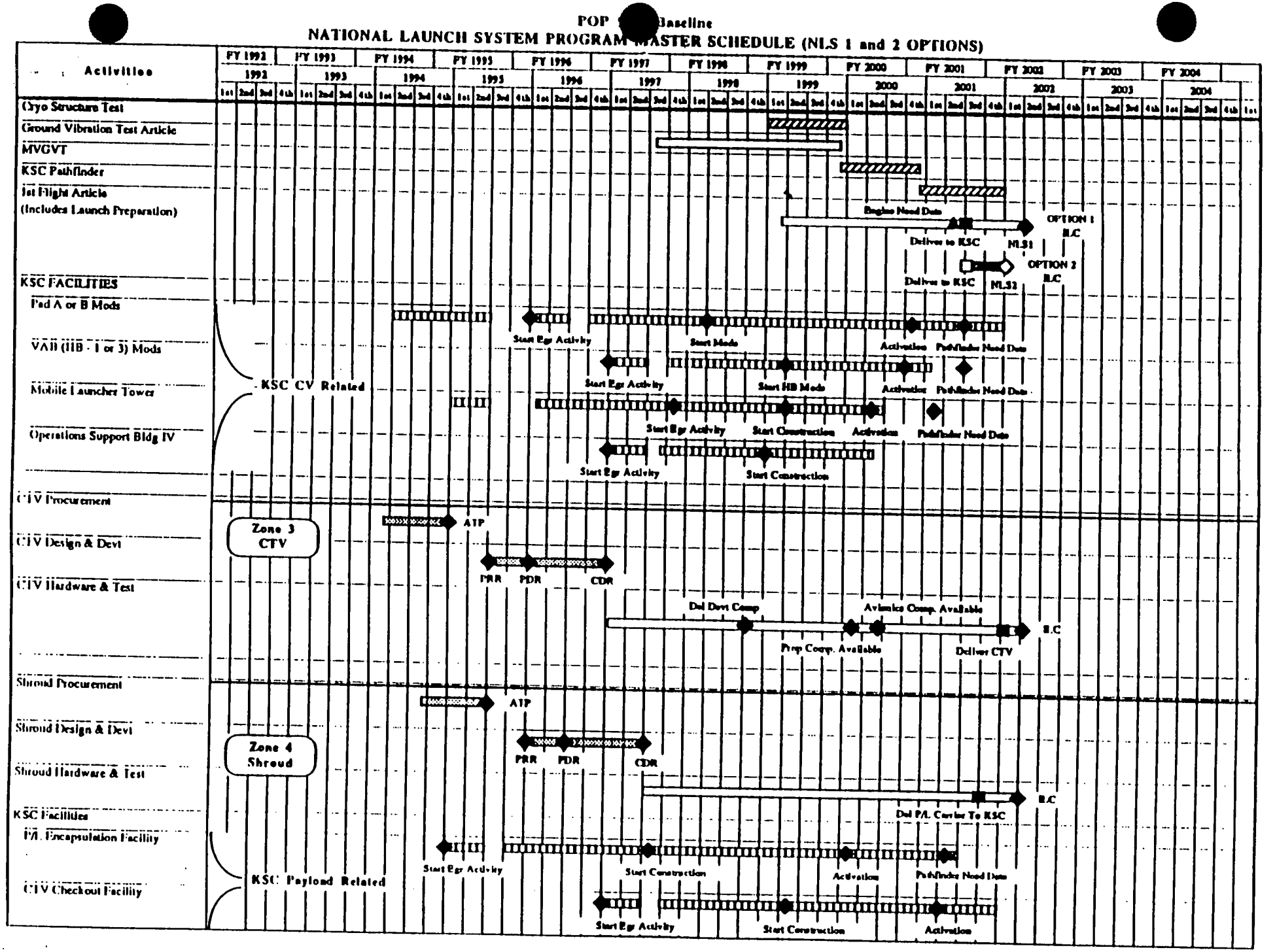


Figure 8-1 (con't)

National Lanuch System
MSFC In-House Manpower

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
STME									
Core Vehicle									
CTV									
Other									
Totals									

Table 8-1

National Lanuch System
MSFC In-House Manpower

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Project Office									
Science & Eng.									
Prog. Devel.									
I&PS									
Other									
Totals									

Table 8-2

that require the Associate Administrator's attention are compiled into a report by the Program Office using lower level reports. These items are described in sufficient detail to provide a comprehensive understanding of the subject being presented. Also, the recommended solution will be described for any problem that requires a decision by the Associate Administrator.

To provide an overview of the program to the NASA Administrator, pertinent portions of the Associate Administrator's report are summarized and compiled into a report that is presented periodically by the Associate Administrator for (TBD). Reviews by the Administrator of NASA or his deputy are held when approvals to proceed are required, when any controlled item is affected, and as necessary to keep them advised of status. (TBD) management also periodically reviews the program with the MSFC management.

c. MSFC Management Reviews

To keep the Projects Manager at MSFC apprised of the project status, several periodic reviews are conducted with the managers of the operational elements at the Center. Among these are the weekly staff reviews and the monthly progress review. The weekly staff reviews are held with the managers of the Projects Office organizational elements to review accomplishments, technical progress, problem areas, and planned corrective actions. The monthly progress reviews are conducted by the Projects Office Manager. At these reviews, managers present comprehensive reports of the status of their respective areas of responsibility.

The Projects Office Manager conducts the Flight Readiness Review (FRR) in accordance with NMI (TBD) at which all performing organizations present assessments in their respective areas of responsibility. This review is attended by Agency managers and it serves to provide final information needed for the NASA decision to launch.

In addition to these reviews, the Projects Office Manager attends formal and informal reviews presented by the contractors depending on the significance of the review and his prior commitments.

The Director, MSFC, regularly reviews projects which involve the Center, including NLS. The Director's Review of the NLS project will occur every four to six weeks. MFSC senior management attends the Director's Review.

d. MSFC Project Reviews

Reviews of performing organizations are conducted with the Project Office sub-system managers presiding. Baseline reviews and progress reviews normally involve project management. Technical reviews and working sessions are held to discuss details of the work to be performed and the contractor's planned approach with both NASA and contractor key personnel present. Other reviews may be conducted by end-item manager in their respective areas of responsibility.

The following baseline reviews at the performing organizations are conducted by the project:

i. The Project Requirements Review (PRR) is the earliest review of the requirements selected to meet the mission objectives. It is accomplished to establish the baseline necessary to proceed with planning and implementation of design/development, with emphasis on preliminary design.

ii. The Preliminary Design Review (PDR) is a formal review of the engineering approach and results in the baseline upon which the detailed design proceeds.

iii. The Critical Design Review (CDR) is the evaluation of the detailed design to the approved design requirements.

This review is accomplished when the detailed design is 90% complete and most of the fabrication drawings are ready for release to manufacturing. It establishes the baseline required to commit the design to production of the designed items. At this stage, emphasis shifts from engineering to manufacturing.

iv. Acceptance Reviews or Preshipment Reviews are conducted to establish the end item configuration baseline required to control changes to manufactured items during the operational phase. These reviews also serve to validate or revise technical documentation so it truly reflects the as-built condition of the item. The documentation is then suitable for use in operating the items and is maintained until mission termination.

v. Performing organizations participate in the Flight Readiness Review conducted by the Projects Office Manager. At that review, they present information concerned with the flight readiness of items for which they have a responsibility and they sign the final endorsement on the Certificate of Flight Worthiness.

Progress reviews are held, at which time, the performing organization makes comprehensive presentations on status, major milestone accomplishments, technical progress, overall project problems, and planned corrective actions to management. These status reviews normally occur monthly for the major contractor and every month for other elements of the project.

Technical progress is included as a part of the progress review, however, specific reviews of the technical aspects are conducted by the Project Office. Generally, these reviews are conducted only as required. Any item not meeting schedule or performance requirements is subject to being reviewed technically.

e. NLS Payload Safety Reviews

The NLS payload safety reviews will be conducted to ensure compliance with the normal system requirements for unmanned space-flight. These reviews will serve to reinforce compliance with the program goal of safety requirements being developed as an integral part of the design specifications and procedures.

10. Controlled Items

a. General

The following items are controlled and require senior management approval before they are changed. Items controlled by the Administrator are contained in the Project Approval Document (PAD) and reported there. An immediate review to determine management action is required when any conditions established for the controlled item are subject to adverse effect or change.

b. Items Controlled by the Administrator

The following items are controlled by the Administrator, NASA, and cannot be changed without his or the Deputy Administrator's approval:

- MOU between NASA and DoD,
- Program management and lead center assignments,
- Total project cost,
- Project objectives and major features of the project as stated in the PAD,
- Interagency and international agreements for cooperative projects involving NLS.

c. Items Controlled by the Associate Administrator, (TBD)

In addition to providing management attention to insure integrity of those items controlled by the Administrator, the following items are controlled by the Associate Administrator for (TBD) and cannot be changed without his approval:

- Any proposed change to items controlled by the Administrator, above, which have been prepared for (TBD) to be submitted to the administrator,
- NLS Project Plan where changes affect the general objectives and approach for accomplishing the project,
- Agreements between (TBD) and the offices of other Associate Administrators,
- Types and quantities of launch vehicles, research and development efforts, and other supporting activities to be procured and the distribution of major effort between in-house elements and contractors.
- Contract implementation mode and headquarters controlled procurements,
- Launch readiness dates,
- Number of launches per year,
- Decision to proceed with production of flight hardware,

d. Items Controlled by the Joint Program Office

The following items are controlled by the Joint Program Office and are not changed without the Program Director's approval, or the approval of personnel within his office, consistent with his delegations of authority including his delegations to the MSFC NLS Projects Manager:

- Any proposed change to items controlled in b. and c. above, which have been prepared under his purview for submittal to the Associate Administrator, (TBD),
- Level II requirements,
- Budget allocations,
- Change Board actions above $(TBD) value,

- Development of new technology requirements,
- Level II controlled milestones and schedules,
- Launch site, mission control center or data processing center selections,
- NLS Project Plan when changes are editorial in nature or merely updating the status reflected therein.

e. Items Controlled by MSFC National Launch System Projects Office

The following items are controlled by the manager, MSFC National Launch System Projects Office and cannot be changed without his approval:

- (TBD)

11. Safety, Reliability and Quality Assurance, and Verification

a. General

Assurance that NLS products are safe, and of appropriate quality to satisfactorily perform during operation, results from the implementation and operation of reliability, quality assurance, verification, and safety functions. These functions include proven techniques and appropriate application as developed by the project and those MSFC offices responsible for these functions at MSFC.

b. Safety

The NLS shall control the risk to humans, or property, and to this end shall adhere to the following safety requirements. The NLS flight and ground operations shall comply with range safety requirements and constraints developed for the NLS by the Air Force Eastern Test Range (AFETR) and the Air Force Western Test Range

(AFWTR). The NLS shall also comply with all federal, state, and local industrial safety regulations.

To comply with requirements to avoid space debris and to ensure safety, the NLS shall provide for safe disposal (including trajectory and debris dispersions) or recovery of all launch vehicle components and all payload equipment's which are not deployed with the payload. Disposal from a high energy orbit shall be to a higher, less trafficked orbit. Disposal from low earth orbit shall be in oceans areas:

- No closer than 200 nmi. from foreign land masses
- No closer than 25 nmi. from U.S. territories and CONUS
- North of 60 degrees south latitude.

Care is taken to avoid redundant effort between safety and other disciplines. As an example, hazard analyses will be conducted in conjunction with FMEA and may be incorporated in the FMEA's in lieu of separate reports.

c. Reliability and Quality Assurance

The NLS Program shall implement the Total Quality Management approach so that TQM goals and NLS Program objectives are completely aligned. A dedication to quality, responsiveness, and economy are the tenets of the program.

d. Verification

The verification approach used by the project will be documented in Project Verification Plans. Visibility of the status of design, verification, and manufacturing is provided at reviews. Verification receives particular emphasis at the baseline reviews. Verification employs a carefully-planned combination of tests and assessments. In essence, any newly designed or unproved equipment will be tested and evaluated to assure compliance with the design requirements levied on it. Designs of equipment that

have previously been verified and flown on similar missions will be verified by assessment only. Equipment is verified as early in the manufacturing process as practical. In addition to verifying the functional performance of the various items of equipment, the compatibility with interfacing equipment will also be verified.

Appendix A - Vehicle
Appendix B - Space Transportation Main Engine
Appendix C - Payload Accommodation System

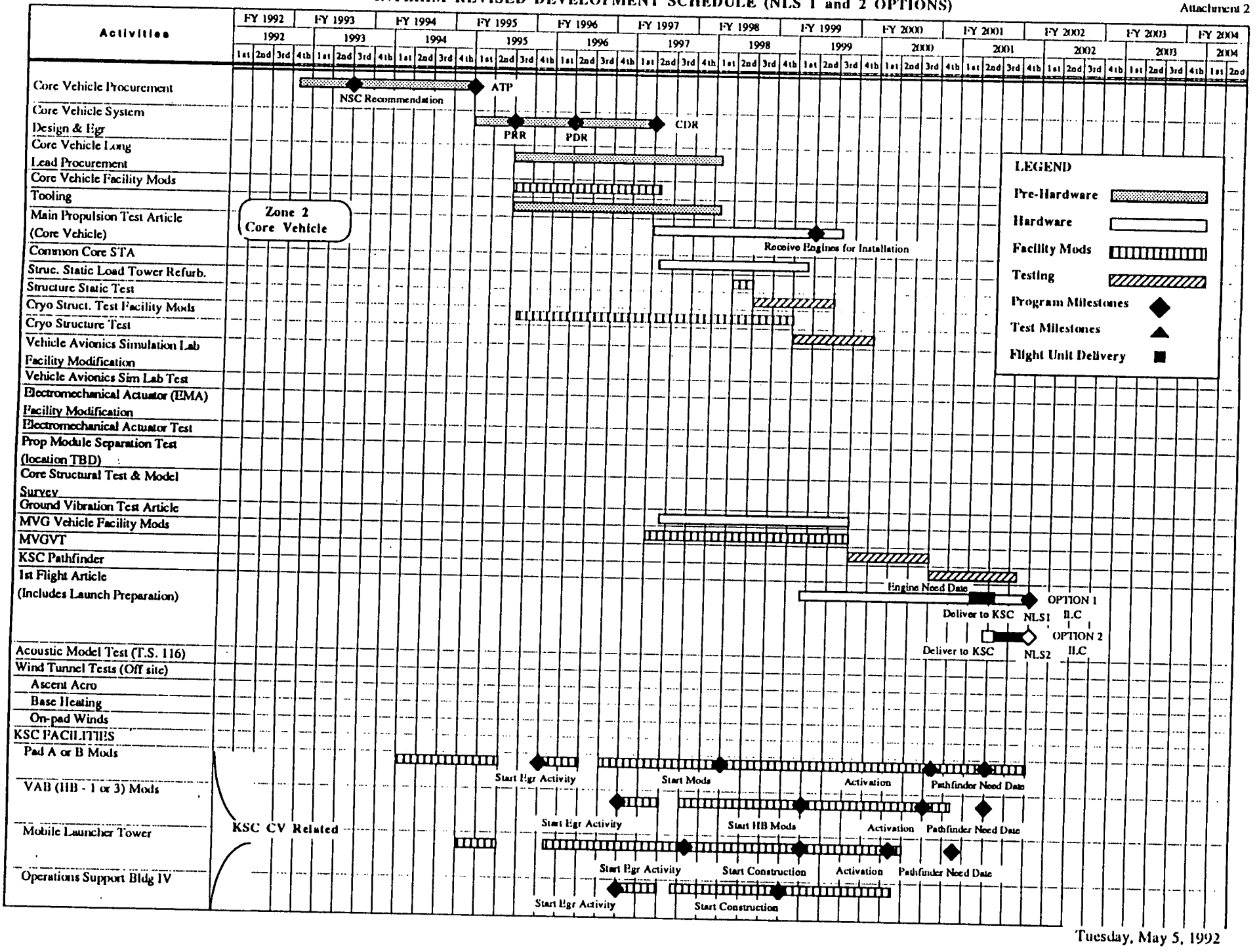
Appendix A

Vehicle

National Launch System
Vehicle Office
Organization

NATIONAL LAUNCH SYSTEM
INTERIM REVISED DEVELOPMENT SCHEDULE (NLS 1 and 2 OPTIONS)

Attachment 2



Tuesday, May 5, 1992

National Launch System
Vehicle
Funding

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Prime Contractor									
Facilities & Equipment									
Project Support									
Totals									

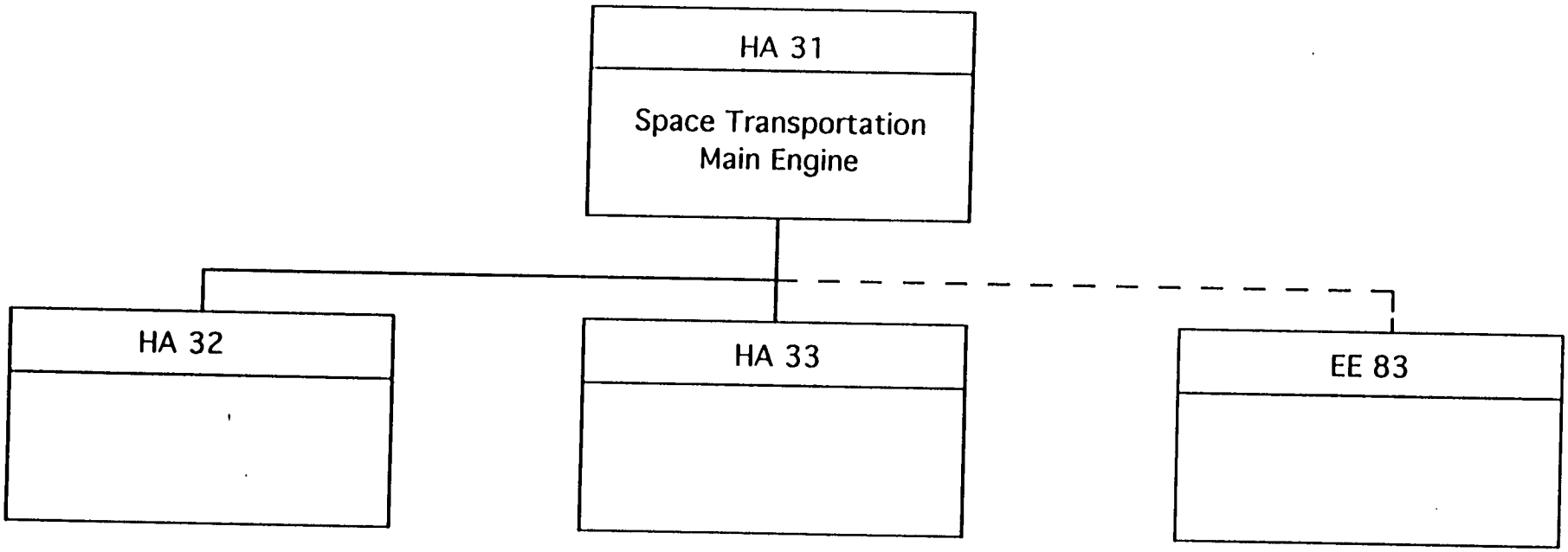
National Lanuch System Vehicle In-House Manpower (FTE)

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Project Office									
Science & Engr									
Prog. Develop.									
I & PS									
Other									
Totals									

Appendix B

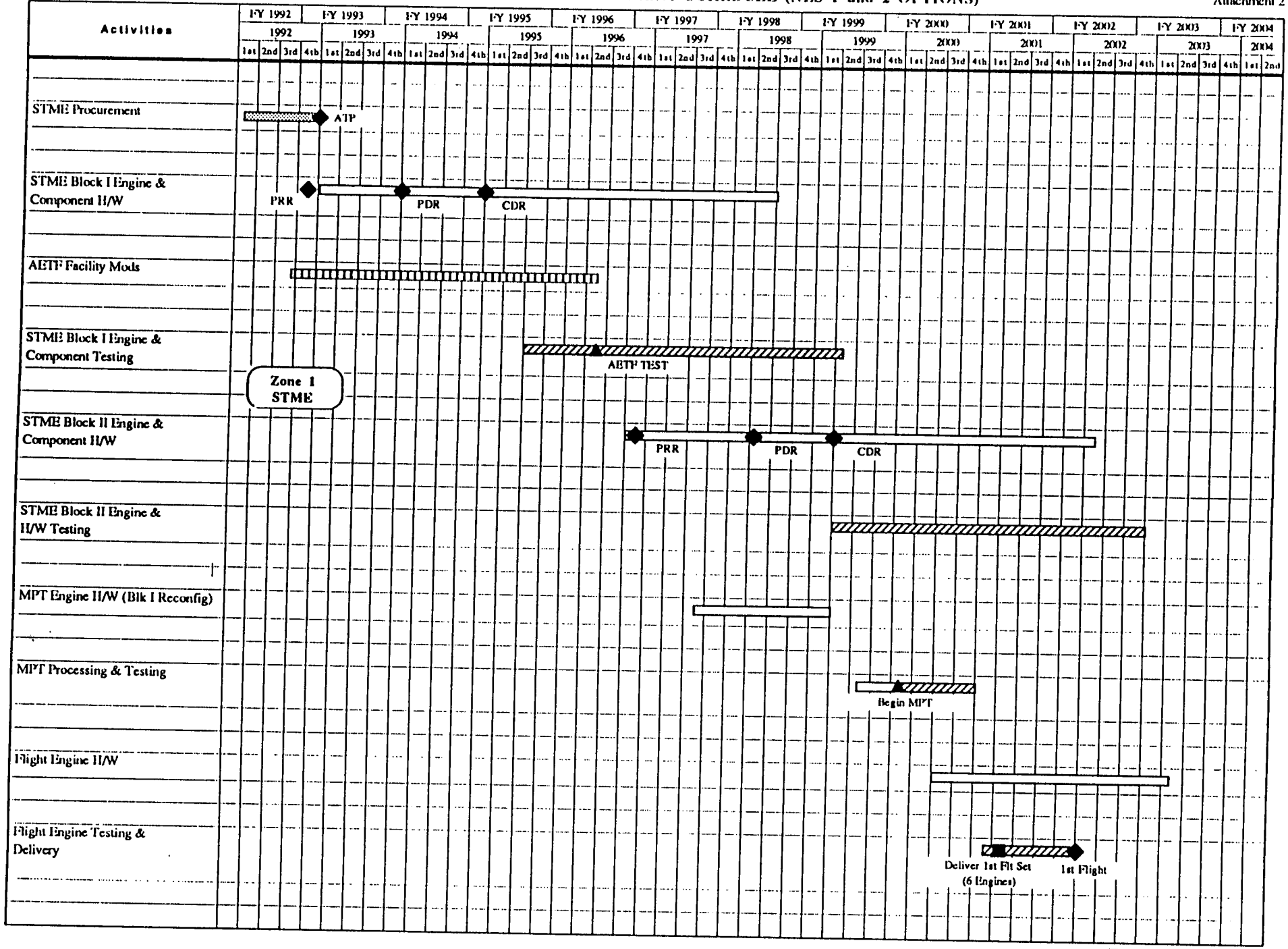
Space Transportation Main Engine

National Launch Systems
Space Transportation Main Engine
Organization



NATIONAL LAUNCH SYSTEM
INTERIM REVISED DEVELOPMENT SCHEDULE (NLS 1 and 2 OPTIONS)

Attachment 2



Tuesday, May 5, 1992

National Launch System
Space Transportation Main Engine
Funding

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Prime Contractor									
Facilities & Equipment									
Project Support									
Totals									

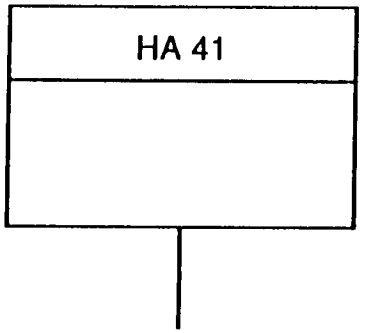
National Lanuch System
Space Transportation Main Engine
In-House Manpower
(FTE)

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Project Office									
Science & Engr									
Prog. Develop.									
I & PS									
Other									
Totals									

Appendix C

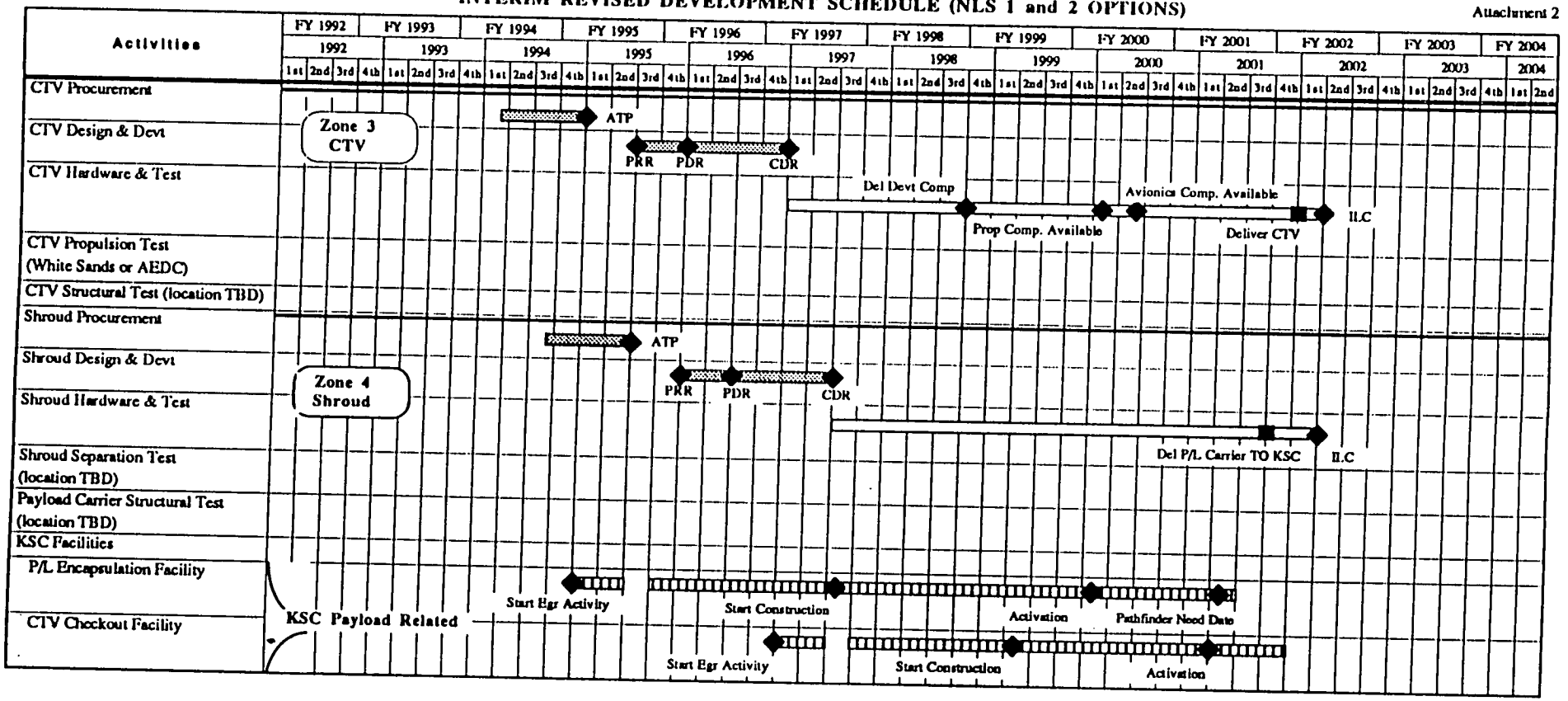
Payload Accommodation System

National Launch System
Payload Accommodation System
Organization



NATIONAL LAUNCH SYSTEM
INTERIM REVISED DEVELOPMENT SCHEDULE (NLS 1 and 2 OPTIONS)

Attachment 2



National Launch System
Payload Accomodation Systems
Fundings

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Prime Contractor									
Facilities & Equipment									
Project Support									
Totals									

National Lanuch System
Payload Accommodation Systems
In-House Manpower
(FTE)

Item	FY-93	FY-94	FY-95	FY-96	FY-97	FY-98	FY-99	FY-00	Bal to Complete, Totals
Project Office									
Science & Engr									
Prog. Develop.									
I & PS									
Other									
Totals									

1.2.12 Summary Reports

The task reports contained in sub-paragraphs 1.2.12.1 through 1.2.12.5 are summaries of reports, articles, memoranda and directives that pertain to the National Launch System. USBI performed this task in order to gain a better understanding of public, agency, and congressional opinion of the program in an attempt to identify actions that could be taken to gain full support.

1.2.12.1 The Gavin Report

1.2.12.2 Phased Program from "Ups and Downs of the New Space Launcher"

1.2.12.3 NASA Headquarters direction to JPO

1.2.12.4 NLS Funding Flow

1.2.12.5 National Space Policy Directive #4

1.2.12.1 The Gavin Report

Task report 1.2.12.1 is a summary of The Gavin Report, the recommendations of the National Research Council's (NRC's) Committee on Earth-to-Orbit Transportation Options regarding the various space transportation options that are available to the United States.

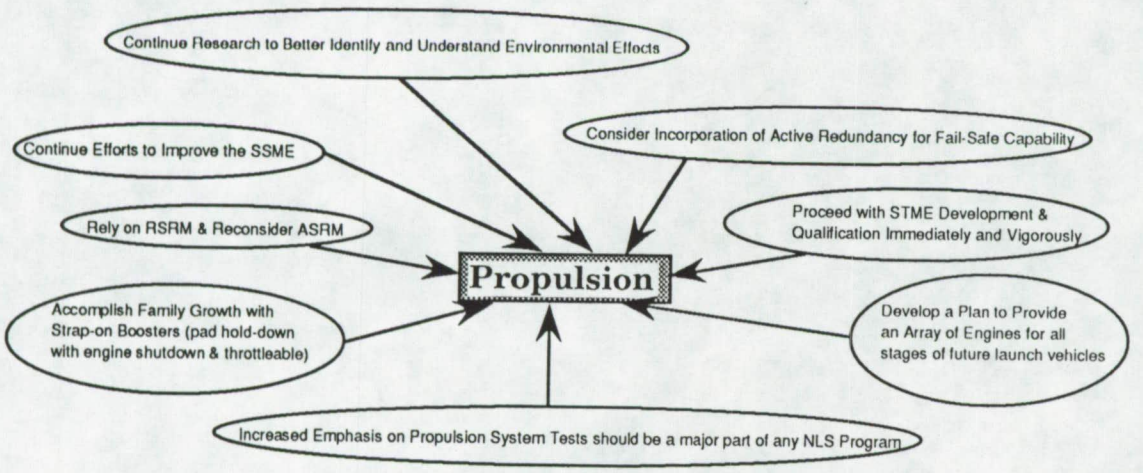
"From Earth to Orbit" - The Gavin Report

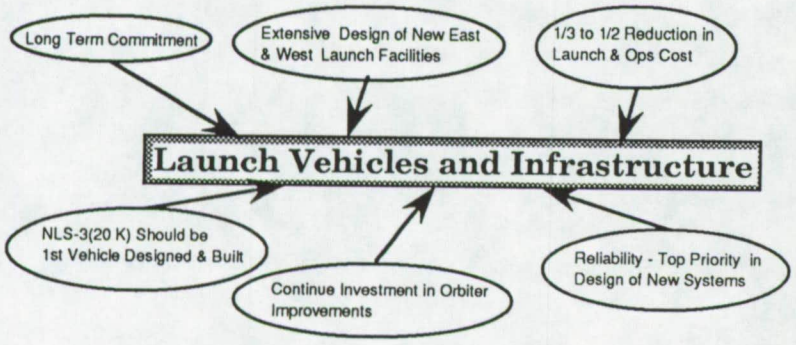
Task
Assess the requirements, benefits, technological feasibility, & roles of Earth-to-orbit transportation options that could be developed in support of the national space program.

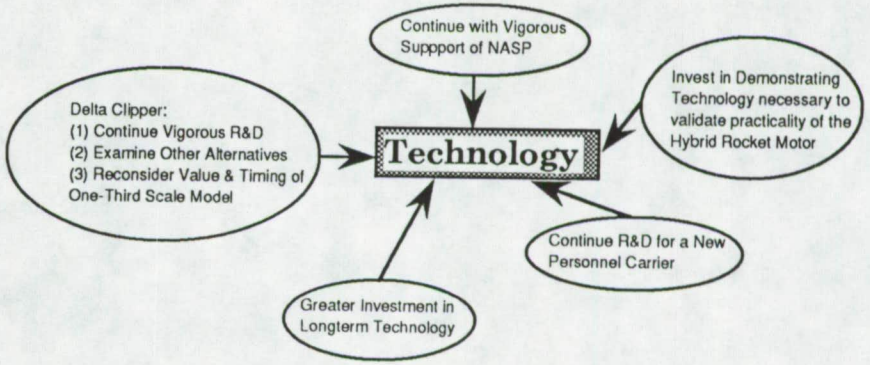
Focus:
- Cost
- Reliability
- Resiliency

Constraints:
- The Way We Do Business
 - Launch Vehicle Assy
 - Payload Processing
 - Launch Pad Design & Availability
- Lack of Vehicle and Propulsion System Robustness

Recommendations:







"From Earth to Orbit" - The Gavin Report

Task
Assess the requirements, benefits, technological feasibility, & roles of Earth-to-orbit transportation options that could be developed in support of the national space program.

Focus:
- Cost
- Reliability
- Resiliency

Constraints:
- The Way We Do Business
 - Launch Vehicle Assy
 - Payload Processing
 - Launch Pad Design & Availability
- Lack of Vehicle and Propulsion System Robustness

Recommendations:

Propulsion

Continue Research to Better Identify and Understand Environmental Effects

Proceed with STME Development & Qualification Immediately and Vigorously

Rely on RSRM & Reconsider ASRM

Develop a Plan to Provide an Array of Engines for all stages of future launch vehicles

Increased Emphasis on Propulsion System Tests should be a major part of any NLS Program

Accomplish Family Growth with Strap-on Boosters (pad hold-down with engine shutdown & throttleable)
Continue Efforts to Improve the SSME

Consider Incorporation of Active Redundancy for Fail-Safe Capability

Launch Vehicles and Infrastructure

Long Term Commitment

Extensive Design of New East & West Launch Facilities

1/3 to 1/2 Reduction in Launch & Ops Cost

Reliability - Top Priority in Design of New Systems

NLS-3(20 K) Should be 1st Vehicle Designed & Built

Continue Investment in Orbiter Improvements

Technology

Delta Clipper:
(1) Continue Vigorous R&D
(2) Examine Other Alternatives
(3) Reconsider Value & Timing of One-Third Scale Model

Continue with Vigorous Suppport of NASP

Invest in Demonstrating Technology necessary to validate practicality of the Hybrid Rocket Motor

Continue R&D for a New Personnel Carrier

Greater Investment in Longterm Technology

1.2.12.2 Phased Program from "Ups and downs of the new space launcher"

Task report 1.2.12.2 is a pictorial representation of the phased program approach laid forth in the article titled, "Ups and downs of the new space launcher" published in Aerospace America's June 1992 issue and authored by Jerry Grey, editor at large.

Phased Program from "Ups and Downs of the new space launcher"

FY93 | FY94 | FY95 | FY96 | FY97 | FY98 | FY99 | FY00 | FY01 | FY02 | FY03 | FY04

Phase 1 $1.2B

- **NLS3 (20K)** - System Definition & Design
- **STME "Block 1"** - Complete Development
- **Advanced Technologies** - Component Demonstration (Al-Li, EMA, VHM)

Δ NLS3 -1st Flt.

Phase 2 $3.8B

- **NLS3** - Complete Development & First Flight
- **STME** - Flight Qualification
- **Advanced Technologies** - Continue
- **NLS3 Launch Facility** - Begin Upgrades
- **NLS2 (50K)** - Initiate Definition

Phase 3 $1.9B

- **NLS2** - Complete Development & First Flight
- **Launch Facilities** - Complete All Upgrades
- **Advanced Technologies** - Complete Most
- **NLS2 Upper Stage (US)** - System Definition & Design
- **Cargo Transfer Stage** - System Definition & Design

Δ NLS2 -1st Flt.

Phase 4* $1.2B

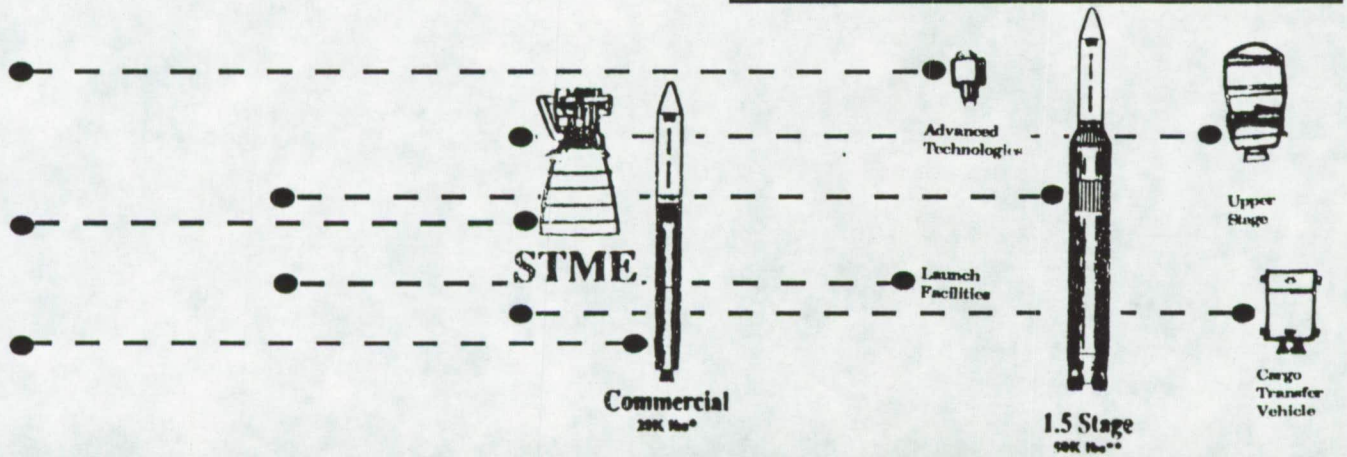
Δ NLS2 w/ US -1st Flt.

- **NLS2 w/ US** - Complete Development
- **Cargo Transfer Stage** - Complete Development

** Dependant upon SSF & SEI Schedules & Funding*

Results

- **Two-stage small launcher with a single-engine first stage (NLS3)**
- **Common one-and-a-half-stage core vehicle with an ultimately recoverble four-engine boost stage and a two-engine sustainer (NLS2)**
- **Upgrade of existing high-energy upper stages with "kits" to adapt to special needs (i.e. SSF support)**
- **Common engine for all configurations**
- **Advanced fault-tolerant avionics**
- **Vehicle Technology Advancements**
- **Automated groung servicing**
- **Upgraded launch facilities**

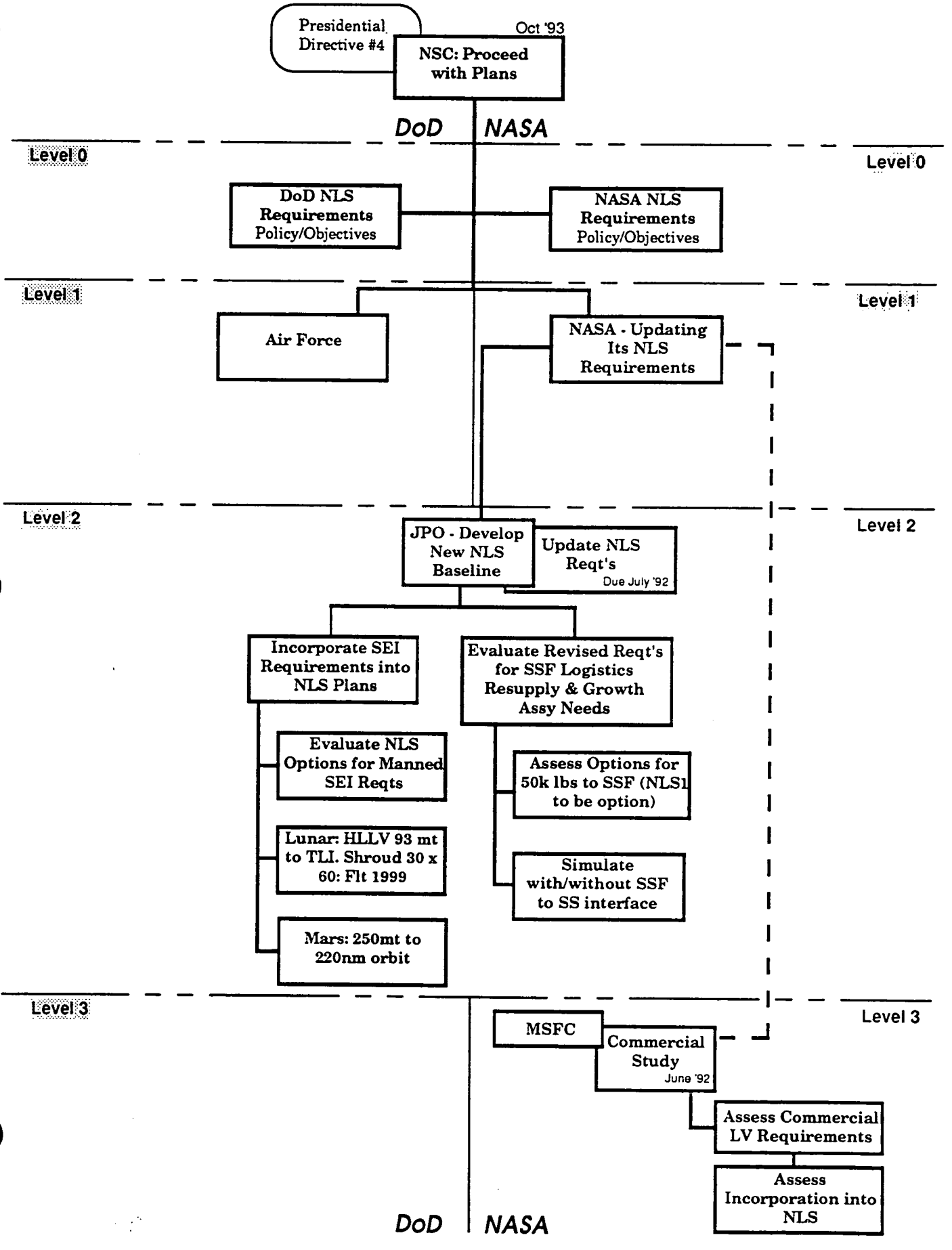


1.2.12.3 NASA Headquarters direction to JPO

Task report 1.2.12.3 is a pictorial representation of the NASA headquarters direction to the Joint Program Office (JPO) given in a Ron Harris letter to Colonel Graham dated May 11, 1992.

NASA HDQ Direction to JPO

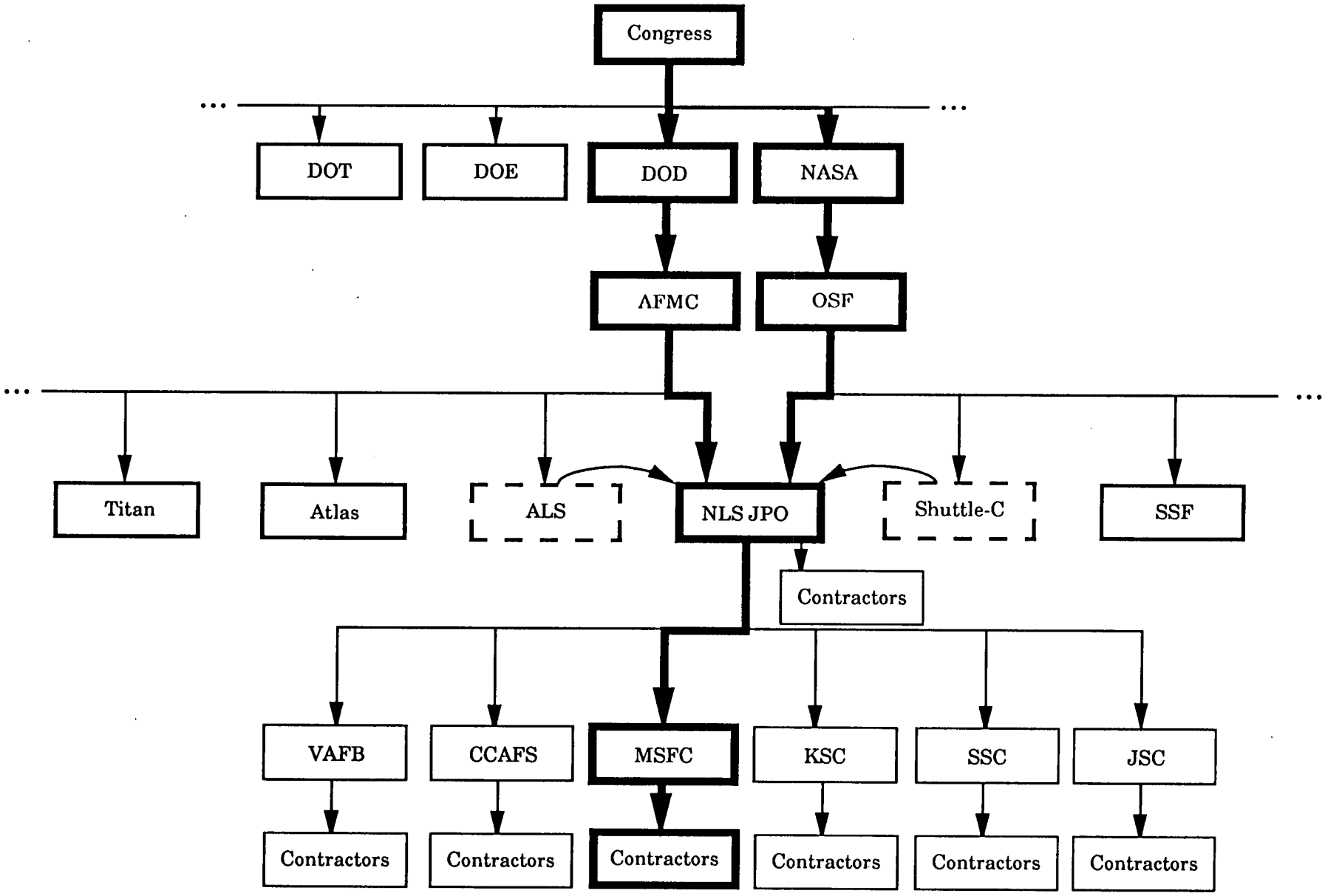
(Ron Harris Letter to Colonel Graham - May 11, 1992)



1.2.12.4 NLS Funding Flow

Task report 1.2.12.4 is a flow process showing NLS funding beginning with Congress and proceeding down to Marshall Space Flight Center (MFSC) and MSFC contractors. This flow chart was created to bring insight into the funding process, identifying the organizations responsible for distribution of funds and the organizations eligible to receive them.

NLS Funding Flow



1.2.12.5 National Space Policy Directive #4

Task report 1.2.12.5 is a summary of the National Space Council's Space Policy Directive #4 authorized by President Bush. This summary separates the directive into three sections: introduction, strategy, and guidelines; and identifies the key points in each section.

National Space Policy Directive # 4–President Bush's directive

Introduction

"Assured access to space..."
"Safe and reliable access"
"Reduce the costs"
"Exploit attributes a/manned and unmanned launch and recovery systems"
"Encourage growth of U.S. private sector space transportation"

Strategy

- Unmanned, but man-rateable (define man-rateable)
- Improve Launch capability
- Reduce op costs
- Improve reliability
- Improve responsiveness
- Improve mission performance

Guidelines

STS

- Existing vehicles through 1990's
- Space Shuttle used only for missions requiring manned presence or other Shuttle unique capabilities.

NLS

- Improve launch capability
- Reduce op costs
- Improve reliability
- Improve responsiveness
- Improve mission performance
- Support a range of medium to heavy-lift performance
- Facilitate evolutionary change
- May take advantage of existing components
- First flight of 1999 (decided in FY93)
- Joint Dod-NASA program

1.2.13 Opportunities for Change Matrices

Task report 1.2.13 is a set of matrices developed to organize the many ideas for reducing costs presented at the Program and Contractors' Managers' Reviews and by the Red Teams. The first matrix lists the opportunities for change by process, program review number (1,2 and 3), and by recommending organization. The second matrix lists the opportunities for change by program review number (1,2, and 3) and recommending organization.

UNITED TECHNOLOGIES USBI

National Launch System Opportunities for Change Matrices

May 6, 1992

NLS Opportunities for Change

Introduction

- Many potential methods for reducing NLS costs have been identified at the Program and Contractors Manager's Reviews.

- The two matrices that follow attempt to organize the many ideas that have been presented. Matrix I lists the opportunities for change by Process, Program Review Number (1,2, & 3) and by the recommending organization. Matrix II lists the opportunities for change by Program Review Number(1,2, & 3) and Recommending Organization.

NLS Opportunities for Change

Part I: Opportunities for Change Matrix I

Organized by Process (Acquisition, Design, Operational, & Management), Program Review Number (1,2, & 3) and Recommending Organization

Part 2: Opportunities for Change Matrix II

Organized by Program Review Number (1,2, & 3) and Recommending Organization

Part I: Opportunities for Change Matrix

Organized by Process, Program Review Number , and Recommending Organization

Acquisition Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
1. Establish and implement a phased program, (i.e., buy "by the yard")	√	√	√	√					√		√					
2. Establish a tailored set of specifications, standards, and documentation			√			√		√	√		√			√		√
3. Employ a contractor proposed or integrated CDRL List			√						√							√
4. Implement multi-year budget; Maintain Commitment to Program and Funding Levels			√			√		√								√
5. Recompete Systems and Components -- Allow for Changes			√	√												
6. Streamline Subcontract Policies			√					√								
7. Use Commercial Practives or Develop Government/Contractor "Partnership"																√
8. Incorporate Incentives for Continual Product Improvement																√
9. Parts/Material Procurement - Small-Lot Buys, Over Specification - Lack of Intra-Program Coordination																√
10. Pursue Improvements Proposed by NASA AA for Procurement																√

Acquisition Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
11. Improve Budget Process - Prevent Yearly Replanning - Reduce POP Process Time - Reduce Level of Detail as one goes up Management Chain - Consolidate Reporting Requirements - Provide Funding Margins																√
12. Base Planning on Realistic Assumptions - Cultural Changes - Degree of Inheritance for Hardware																√

Design Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
1. Implement Concurrent Engineering	√	√	√		√	√	√	√	√		√	√				√
2. Stretch Core Stage for Increased Performance	√	√						√								
3. STME - Isp Improvement - Nozzle Area Ratio - Improved Mixture Ratio and Thrust Trim Tolerance - Reduced Flight Effects - Increased Engine Thrust		√						√ √		√ √ √ √ √						
4. Identify Evolutionary Growth to Support SEI		√							√		√					
5. Definition of Man Ratable		√	√								√					
6. Eliminate Engine Out Philosophy		√			√			√			√					
7. Employ Reusable Hardware		√									√					
8. Reduce/Standardize Payload Accommodations		√					√		√							
9. Produce and Launch Vehicles Using Identical Procedures, (i.e., no distinction between DoD, Civil, and Commercial)		√	√				√		√		√					
10. Employ Castor Motors		√						√								

Design Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
11. Modify Payload Delivery Orbit		√						√								
12. Avoid Use of Solids		√					√									√
13. Minimize Cyrogenic Quick Disconnects		√					√									√
14. Use Built-In Diagnostic Capability in Flight Hardware		√				√	√									√
15. Redesign NLS1 to enhance commonality		√										√				
16. Implement advanced guidance/fault tolerant avionics		√				√										
17. Introduce manufacturing technologies – Auto. welding and n-de – Extruded weldalite barrels – Auto. assembly & robotics – Auto. composite processes		√				√										
18. Incorporate AL-Li Alloy into structural design			√												√	
19. Develop complete Phase A/B technical definition including stable, validated requirements which are reflected in the design			√	√		√		√	√		√		√			√
20. Employ automated engineering analysis and data tracking			√			√										

Desi Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
21. Expendable hardware design should include – Low complexity system design – Fewer parts & materials			√			√										
22. Employ statistical progress control			√			√										
23. Allow insertion of new technologies			√	√												
24. Establish robust design margins to minimize number of major tests to flight certify launch vehicle			√	√												
25. Employ an existing system for CTV function			√		√											
26. Incorporate new technology in the area of: – Laser ordnance – TVC systems		√	√		√ √	√										
27. Avoid design selection before complete requirements definition			√					√								
28. Eliminate overly specified and constrained solutions			√					√								
29. Trade-off requirements to justify value-added versus cost – Cargo Transfer Vehicle – Natural Environment prot. – Cryogenic fluid loading/unloading			√								√					√

Design Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
29. (Con't.) – No-pad access – Concurrent STS operations – System security – Payload assignment changes – Reliability/dependability – Growth capability – STME – STS compatibility – Surge – Resiliency			√								√					
30. Direct Labor implementation – Improve and automate work instruction system – Staff according to skill level required			√			√										
31. Participation of government personnel as hands-on team members for development testing and use of government labs/manufacturing facilities																√
32. Remove "desirements" from the requirements																√
33. Establish a computer driven system simulation to define acceptable operational limits on subsystems																√

Design Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
34. Establish LRU MTBF levels high enough so that operational testing is not required to assure systems reliability.																√
35. Insure adequate margins are maintained throughout development																√
36. Recover and reuse high value hardware																√

Operational Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
1. Employ single launch site	√	√	√	√	√	√					√					
2. Employ operations technology – Automated launch processing – Autonomous launch operations – Automated propellant loading – Computerized management system	√	√	√ √		√	√ √ √ √					√ √					
3. Employ ship and shoot philosophy		√						√			√					
4. Employ factory of the future concept		√									√					
5. Standardize payloads and payload operations		√									√					
6. Decrease program support and reserve at 25th unit		√						√								
7. Launch site operations – Minimize handling – Simplify assembly functions – Use common flight and ground software – Provide redundant capability for critical ground testing resources		√	√		√		√ √ √ √									√ √ √ √
8. Support function – Re-engineer from bottom-up to provide only value-added support – Simplify and automate support process		√	√			√ √										√

Operational Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
8. (Con't.) – Organize and staff according to product activity required – Eliminate departmental barriers						√ √										
9. Support culture – Implement design to operations – Eliminate duplicate test and checkout procedure – Rely on VHM and BITE data – Eliminate extensive paper flow requirements			√		√											
10. Employ remote payload and mission support operations			√						√							
11. Critically reassess operational requirements to insure that true requirement exists; establish cost vs. value-added																√
12. Clearly separate operations phase from development and adjust test requirements, sustaining engineering, support, etc. accordingly																√

Management Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
1. Implement design to cost	√	√	√	√			√	√	√		√		√			√
2. Implement operate to cost			√								√					
3. Employ early use of protyping to avoid risk	√			√												√
4. Enable shorter span times by firm up-front requirements and freezing requirements/configuration at PDR	√	√	√						√							√
5. Employ new CER's; Current CER's based on history, old way of doing business		√	√					√	√							√
6. Eliminate duplication and scars from program costs (300K capability, duplicate launch sites)		√		√												
7. Employ process oriented system to track program progress and charges		√		√												
8. Employ improved cost/schedule control system			√					√								
9. Employ electronic access/delivery and database for reporting; track and report at value added item level			√			√										
10. Limit degree of Government oversight			√			√			√							√

Management Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
11. Employ a strong integration effort			√			√										
12. Reviews – Replace classic PRR, PDR, CDR with major end item reviews – Organize into "Project End Item Groups"			√	√												
13. Teamwork – Clean hand-offs – Multiple organizations responsible for single functions			√										√			
14. Data flow and quality – Number of organizations/interfaces – Information technology (UNIS) – Process modeling (DSS)			√										√			
15. Metrics – Measure what's important – Keep it simple – Make it visible – Involve everyone – Instill sense of urgency			√										√			
16. Implement disciplined systems engineering and management practices			√		√											

Management Process
"Opportunities for Change"

Opportunity	Program Review			Recommending Organization												
	1	2	3	GDSSD	LMSC	MMAG	MDSSC	RI	TRW	STPT	USBI	MMMSS	Boeing	Red Tm	MSFC	LZ Inpts
17. Implement configuration control early			√					√								√
18. Eliminate excessive meetings via telecons, E-mail, and video conferences			√					√								
19. Eliminate production before development and test phases complete			√					√								
20. Co-locate Level I/II/III			√								√					
21. Simplify chain of command			√								√					√
22. Downscope/eliminate Decision Support System			√								√					
23. Focus development activities in order to insure contractor, administration and congressional support																√
24. Define the need for NLS and sell the program based on need																√

Part 2: Opportunities for Change Matrix II

Organized by Program Review Number (1,2, & 3) and Recommending Organization

NLS Opportunities for Change - 11/6/91 Review

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Acquisition Process - Implement phased approach	GDSSD	1			
Cost - Implement Design to Cost	GDSSD	1			
Risk - Employ early use of prototyping	GDSSD	1			
Design - Implement concurrent engineering	LMSC	1			
Launch Site - Employ KSC-only option	MMAG	1			
Technology - Automated launch processing - Autonomous launch operations - Automated propellant loading - Computerized management system	MMAG	1			
Cost - Implement Design to Cost	MDSSC	1			
Design - Stretch Core Stage for increased performance -- eliminate some degree of commonality between vehicles	RI	1			
Schedule - Reduce DDT&E schedule	TRW	1			
Cost - Implement Design to Cost	TRW	1			

NLS Opportunities for Change - 1/15-16/92 Review

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
STME - Isp improvement - Nozzle area ratio - Improved mixture ratio and thrust trim tolerance - Reduced flight effects - Increased engine thrust (650K)	STPT	2		-236K	
Evolution - Identify growth to support SEI	USBI	2			
Operability - Single launch site - Definition of manratable - Eliminate engine out - Ship and shoot - Reusable hardware - Factory of the future - Standardized payloads and payload ops - Automated c/o and launch - Technology advancements	USBI	2			
Program Acquisition - Implement phased approach	USBI	2			
Evolution - Identify growth to support SEI	TRW	2			
Design - Reduce payload accommodations	TRW	2			
Design - Implement TQM, CPI	TRW	2			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Schedule - Shorten development span times; Enable by firm up-front requirements and freezing requirements/configuration at PDR	TRW	2			
Standardization - Processes - Specifications - Hardware design	TRW	2			
Program Acquisition - Procurement efficiency; use block buys	TRW	2			
Cost - Implement Design to Cost	RI	2			
Design - Eliminate engine out requirement	RI	2		$10-20M	
Design - Employ castor motors	RI	2		$6-21M	
Design - Modify payload delivery orbit	RI	2		$5-10M	
STME - Increase thrust and Isp	RI	2			
Design - Reduce core stage commonality	RI	2			
Cost - Implement revised CERs for core stage	RI	2		$25M	
Support Function - Decrease program support and reserve at 25th unit	RI	2		$16M	
Launch Operations - Employ ship and shoot	RI	2		$2M	

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Launch Site - Avoid use of solids - Minimize cryogenic quick disconnects - Minimize handling - Simplify assembly functions at launch site - Use common flight and ground S/W - Provide redundant capability for critical ground testing resources - Use built-in diagnostic capability in flight Hardware - Employ concurrent engineering - Standardize payload accommodations	MDSSC	2			
Design - Go away from a HLLV to a more common concept to provide the 80K capability	MMMSS	2			
Design - Implement concurrent engineering	MMAG	2			
Operability - Implement information management system	MMAG	2			
Launch Site - Launch from CCAFS only	MMAG	2			
Design - Implement advanced guidance/fault tolerant avionics	MMAG	2			
Support Function - Delete non-value added standards and regulations - Simplify and automate process	MMAG	2			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
<u>Manufacturing Technology</u> - Automated welding and non-destructive evaluation - Extruded Weldalite barrels - Automated assembly and robotics - Automated composite processes	MMAG	2			
<u>Operations Technology</u> - Automated launch processing - Automated launch operations - Built-in-test, Built-in-test-equipment - Automated propellant loading - Laser ordnance, Insensitive munitions	MMAG	2			
<u>Design</u> - Eliminate engine out requirement	LMSC	2			
<u>Cost</u> - Reduce duplication and scars from program costs (300K capability, duplicate launch sites)	GDSSD	2			
<u>Program Control</u> - Employ process oriented system to track program progress and changes	GDSSD	2			

NLS Opportunities for Change - 3/19-20/92 Review

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Documentation - Establish a tailored set of specifications/standards	Red Team	3			
Structures - Incorporate Aluminum - Lithium Alloy into design	MSFC	3			
Design Philosophy - Implement concurrent engineering for robust quality	MMMSS	3			
Procurement Policy - Specify only value-added Government standards and reporting requirements - Electronic access/delivery and database for reporting; Track and report at value added item level	MMAG	3			
Design Philosophy - Implement concurrent engineering approach/Integrated Product Development Teams - Drive validated requirements into engineering design early - Common integrated program database - Automate engineering analysis and data tracking	MMAG	3		36%	
Procurement Strategy - Set validated requirements early - Maintain commitment to program and funding levels - Limit oversight to smallest organization - Strong integration effort	MMAG	3			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
<u>Support Function</u> - Re-engineer from bottom-up to provide only value-added support - Automate support products - Organize and staff according to product activity required - Eliminate departmental barriers	MMAG	3		30%	
<u>Direct Labor</u> - Improve and automate work instruction system - Improve and automate processes - Staff according to skill level required	MMAG	3		40%	
<u>Design Philosophy - Recurring</u> - Low complexity system design - Fewer parts & materials - Statistical process control	MMAG	3			
<u>Production and Launch Processes</u> - All vehicles are produced and launched using identical processes and procedures, i.e., no distinction between DOD, Civil, and Commercial	MDSSC	3			
<u>Launch Site</u> - Establish a single, shared launch site	GDSSD	3			
<u>Program Acquisition</u> - Establish a phased program, i.e., buy "By-the-yard"	GDSSD	3			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Reviews - Replace classic PRR,PDR, CDR with major end item reviews - Organize into "Project End Item Groups"	GDSSD	3			
Program Acquisition - Recompete systems and components -- allow for changes	GDSSD	3			
Technologies - Allow insertion of new technologies	GDSSD	3			
Prototype - "Go to work" to deliver prototype H/W	GDSSD	3			
Margins - Establish robust design margins to minimize number of major tests to flight certify the launch vehicle	GDSSD	3			
Cost - Implement Design to Cost	GDSSD	3			
Requirements - Allow requirements tailoring	GDSSD	3			
Front-End Engineering - Employ Good system design during front-end -- highest leverage in achieving program cost goals	Boeing	3			
Teamwork - Clean hand-offs - Multiple organizations responsible for single functions	Boeing	3			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Data Flow & Quality - Number of organizations/interfaces - Information technology (LMCS) - Process modeling (DSS)	Boeing	3			
Priorities - Good system design - Good detail design - Good management quality - Good product quality	Boeing	3			
Metrics - Measure what's important - Keep it simple - Make it visible - Involve everyone - Instill sense of urgency	Boeing	3			
Costs - Implement Design to Cost	Boeing	3			
Mission - Use NLS1 for SSF mission	LMSC	3	$2.665B less than 2.5 stage		
CTV - Use an existing system for CTV function	LMSC	3	$137.7M		
Launch Site - Employ KSC-only option	LMSC	3	$854M	$1.084B - Oper. & Support over 20 YR LC	
Technology - Laser ordnance - TVC systems	LMSC	3	$101,000 (LO)		

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
<u>Support Culture</u> - Implement Design to Operations - Eliminate duplicate test and c/o procedure - Assess risk management - Deliver completed vehicle elements - Rely on VHM & BITE data - Eliminate extensive paper flow requirements - Invest in cost effective launch processing technologies - Implement disciplined systems engineering and management practices - Employ effective management systems	LMSC	3		$2.1B LCC over 20 yrs (183 launches)	
<u>Documentation</u> - Increased specification tailoring and commercial applications	RI	3	5-15% of LCC		
<u>Requirements</u> - Freeze requirements and avoid midstream requirements change	RI	3	-		
<u>Design</u> - Avoid design select before full requirements definition	RI	3	-		
<u>Organization</u> - Implement concurrent engineering (CFT's, PDT's)	RI	3	10-20% of LCC		
<u>Acquisition</u> - Streamline subcontract policies	RI	3	1-3% of LCC		
<u>Configuration Management</u> - Implement configuration control early	RI	3	-		

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Budget - Implement multi-year budget	RI	3	10-22% of LCC		
Design - Eliminate overly specified and constrained solutions	RI	3	5-15% of LCC		
Program Planning - Employ improved cost/schedule control system	RI	3	-		
Meetings - Eliminate excessive meetings via telecons, E-mail, and video conferences	RI	3	1-3% of LCC		
Schedule - Eliminate production before development and test complete	RI	3	-		
Cost - Implement Design to Cost	RI	3	5-15% of LCC		
Management - Reduce government oversight process	TRW	3			
Schedule - Employ shorter schedules through enabling development process	TRW	3			
Requirements - Improve requirements discipline	TRW	3			
Documentation - Tailor to design approach and program strategy	TRW	3			
CDRL's - Employ contractor proposed list and electronic media	TRW	3			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Cost - Employ new cost methodology; Current CER's based on history, old way of doing business	TRW	3			
Launch Processing - Employ remote operations	TRW	3			
Design - Implement concurrent engineering, Integrated Product Development Teams	TRW	3			
Cost - Implement Design to Cost, Operate to Cost	USBI	3			
Organization - Integrate NASA/DOD development and use of vehicle	USBI	3			
Launch Site - Employ common launch site	USBI	3			
Design - Develop complete Phase A/B technical definition	USBI	3			
Requirements - Develop stable,frozen set of requirements	USBI	3			
Management - Co-locate level I/II/III - Simplify chain of command - Down-scope/eliminate Decision Support System	USBI	3			

NLS Opportunities for Change (Con't)

Opportunity	Com-pany	Pgm Review (1,2,3)	Savings		Action
			DDT&E	Per Flight	
Culture - Implement concurrent engineering	USBI	3			
Documentation - Employ tailored specifications	USBI	3			
Technical Cost Drivers - Man-ratable - Engine-out - Cargo Transfer Vehicle - Natural Environment Protection - Cryogenic Fluid Loading/Unloading - No-pad access - Concurrent STS operations - System security - Payload assignment changes - Reliability/dependability - Growth capability - STME - STS compatibility - Surge - Resiliency	USBI	3			

1.2.14 Engineering Demonstration Evaluation Process

Task report 1.2.14 is a flow process developed for evaluating proposed National Launch System engineering demonstrations candidates. The process begins with a series of gates each candidate must go through, then rates each candidate on pertinent program issues, and results in a list of prioritized candidates. Along with the flow process, USBI also developed an evaluation worksheet which calculates a candidates score on each program issue and it's total score based on the rating and weighting values inputted.

Engineering

Demonstration

Initiative

NLS Engineering Demonstration Initiative

Assess Means To

- Increase Early Program Momentum
- Strengthen Engineering Database
- Identify and Minimize Program Risks

NLS Engineering Demonstration Initiative

Evaluation - Approach

- Initiate Study Using NASA's Framework for NLS Engineering Demonstration Initiative

- Define Method(s) to Examine the Validity and Merit of Ideas and Issues.

 - Prepare Sample "Screen with Logic Net
 - Prepare Sample Screen Worksheet

- Provide Candidate Items

NLS Engineering Demonstration Initiative

OBJECTIVES:

- **STRENGTHEN ENGINEERING DATABASE AND PROVIDE MOMENTUM FOR FSD DURING THE DEFINITION PHASE**
- **EARLY RESOLUTION OF ENGINEERING ISSUES RECOGNIZED TO HAVE MAJOR PROGRAM IMPACT POTENTIAL RELATIVE TO:**
 - **— VEHICLE CONFIGURATION/ PERFORMANCE/ ENVIRONMENT/OPERATIONS**
 - **— MANUFACTURING/ TEST APPROACH**
 - **— COST**

SOLID DESIGN REQUIREMENTS FOR FSD RFP

APPROACH:

- **HIGH FIDELITY HARDWARE/TESTS**

GUIDELINES:

- **FOCUS ON NEARTERM ISSUES THAT IMPACT MAJOR NLS DECISIONS AND MILESTONES**
- **ACTIVITY SHOULD COVER NEXT 3 TO 4 YEARS**
- **BUILD IN-HOUSE AND CONTRACTED EFFORT GRADUALLY COMMENSURATE WITH PROJECTED REALISTIC FUNDING LEVELS**
- **DEFINE: ISSUES TO BE ADDRESSED, POTENTIAL IMPACT TO THE PROGRAM, APPROACH TO RESOLUTION, SCHEDULE, ESTIMATED COST, AND END PRODUCT**

MSFC/JACK WALKER

Concept	Factors	Investment Cost	Payback Period	Schedule	Eng/Cost Database	Vehicle Config/Perf/ Eng Issues	Manuf/Test/ Check-Out/ Ops Issues	Program-matic Base	Cost Impact (DDT & E)	Cost Impact (Cost/Flight)	Promotional Value	Total Score(A) 198	Total Score(B) 10
Item #1 Lg Prototype (Not to Scale)	Rating	1	1	2	2	1	0	2	1	2	3		
	Weight	5	4	5	6	8	8	6	8	8	8		
	Score(A)	5	4	10	12	8	0	12	8	16	24	99.0	
	Score(B)	0.3	0.2	0.5	0.6	0.4	0.0	0.6	0.4	0.8	1.2		5.0
Item #2	Rating												
	Weight	5	4	5	6	8	8	6	8	8	8		
	Score(A)	0	0	0	0	0	0	0	0	0	0	0.0	
	Score(B)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
Item #3	Rating												
	Weight	5	4	5	6	8	8	6	8	8	8		
	Score(A)	0	0	0	0	0	0	0	0	0	0	0.0	
	Score(B)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
Item #4	Rating												
	Weight	5	4	5	6	8	8	6	8	8	8		
	Score(A)	0	0	0	0	0	0	0	0	0	0	0.0	
	Score(B)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0

Concept	Factors	Investment Cost	Payback Period	Schedule	Eng/Cost Database	Vehicle Config/Perf/ Eng Issues	Manuf/Test/ Check-Out/ Ops Issues	Program-matic Base	Cost Impact (DDT & E)	Cost Impact (Cost/Flight)	Promotional Value	Total Score(A) Maximum	Total Score(B) Maximum
Example Calculation	Rating	r1	r2	r3	r4	r5	r6	r7	r8	r9	r10		
	Weight	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10		
	Score(A)	Score(A)1	Score(A)2	Score(A)3	Score(A)4	Score(A)5	Score(A)6	Score(A)7	Score(A)8	Score(A)9	Score(A)10	Score (A)	
	Score(B)	Score(B)1	Score(B)2	Score(B)3	Score(B)4	Score(B)5	Score(B)6	Score(B)7	Score(B)8	Score(B)9	Score(B)10		Score (B)

Score(A)i= ri*wi
Score(B)i = Score (A)i*10/Total Score(A) Maximum

Candidates

NLS Engineering Demonstration Initiative

Candidate Categories

- Strengthen Engineering/Cost Base - . . . consider
 - Resolve Known Engineering Issues
 - Perform Trade Studies
 - Verify the Baseline

- Strengthen Programmatic Base - . . . consider
 - System Definition
 - Plans and Strategies
 - Mission and Application Definition

- Strengthen National Resolve - . . . consider
 - Formulate Strong Need Statement
 - Define the Benefits/Return on Investment
 - Provide National Incentive(s)
 - Obtain National Commitment

NLS Engineering Demonstration Initiative

Candidates

Strengthen Engineering Base

- Book keep ADP Engineering Demonstrations
- Test Russian Hardware
- Apply Russian, French Guinea, etc... Techniques & Processes
- Test "System" comprised of Existing Hardware
- Modify Existing ET Interstage
- Modify Existing ASRB Recovery System
- Test Scaled Vehicle with Launch Pad Model
- Test Thermal Insulation in a Hot Trajectory
- Develop Avionics Test Bed
- Develop Database of System Capabilities vs Payload/User Needs

Strengthen National Resolve

- Model Ground Vehicle Assembler, MLP, Pad etc... for Public Demo.
- Model Hydraulic System for Public Demonstration
- Model Electrical Actuator for Public Demonstration

Candidate Definition

1. Issues
2. Impact
3. Approach
4. Schedule - TBD
5. Cost - TBD
6. End Product

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base

- ADP Engineering Demonstrations

 - STME Test/Demonstrations
 - Injector Hot Fire Testing
 - Electromechanical TVC Actuator
 - etc...

 Issue: Engineering Base
 Impact: Verification of the Baseline
 Approach: Book keep ADP Demonstrations & Tests
 Product: Models, Simulations, etc...

- Russian Hardware (engines, launch assemblers/erectors)

 Issue: (1) Engineering Base
 (2) National Resolve
 Impact: (1) Verification of the Baseline
 (2) Assistance to Third World
 Approach: Aquire, blueprint, test, etc... existing Russian Hardware
 Product: Hardware and Data

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base

- Apply ground processing techniques and processes used by Russia, French Guinea, etc...

 Issue: (1) Engineering Base
 (2) National Resolve
 Impact: (1) Verification of Baseline
 (2)Assistance to Third World
 Approach: As stated above
 Product: Data

- Acquire existing test hardware, prototype hardware, commercial hardware and set up a "system"

 Issue: Engineering Base
 Impact: Verification of the Baseline;
 Confirmation of Design Criteria
 Approach: Acquire Hardware and Test (EMA, Structures etc...)
 Product: Hardware and Data

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base

- Modify an existing ET interstage to NLS specifications

 Issue: Engineering Base
 Impact: Verification of the Baseline;
 Confirmation of Design Criteria
 Approach: Design, Fabricate, Assemble, and Test
 Product: Hardware

- Test an existing ASRB recovery system to NLS specifications

 Issue: Engineering Base
 Impact: Verification of the Baseline;
 Confirmation of Design Criteria
 Approach: Perform Parametric Test
 Product: Full -Scale Hardware or Scaled Hardware

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base

- Perform tests of scaled vehicle with Launch Pad model to determine exhaust parameters and impacts

 Issue: Engineering Base
 Impact: Verification of the Baseline;
 Confirmation of Design Criteria
 Approach: Design, Acquire,Fabricate, Prepare Models and Perform Tests
 Product: Engineering Data

- Test Thermal Insulation in a Hot Trajectory

 Issue: Engineering Base
 Impact: Verification of the Baseline;
 Confirmation of Design Criteria
 Approach: Develop Test Plan, Design and Acquire Hardware, Design and Prepare Test Facilities, and Perform Tests
 Product: Hardware and Data

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base

- Avionics System Development Test Bed

 Issue: Engineering Base
 Impact: Verification of the Baseline; Confirmation of Design Criteria
 Approach: Test Avionics Hardware & Software in expanded ALS Flight Simulation Lab
 Product: Avionics Data

- Develop Database of System Capabilities vs Payload/User Needs

 Issue: Engineering Base
 Impact: Definition of Performance Profiles
 Approach: Survery and prepare statistical summation of potential NLS payload characteristics and needs, define the bands and establish vehicle and payload operating characteristics, verify the needs, establish trade benefits
 Product: NLS Payload Requirements

NLS Engineering Demonstration Initiative

Candidates - Strengthen National Resolve

- Ground Vehicle Assembler, MLP, Pad, etc... models

 Issue: National Resolve
 Impact: National Commitment increased through Illustrations & Displays and Education Enhanced
 Approach: Design and Fabricate Models
 Product: Small, Medium, and Full Scale Models

- Hydraulic System Models

 Issue: National Resolve
 Impact: National Commitment increased through Displays & Illustrations and Education Enhanced
 Approach: Design and Fabricate Models
 Product: Model with clear pumps and lines with colored liquids and particles

NLS Engineering Demonstration Initiative

Candidates - Strengthen National Resolve

- **Electrical Actuator Models**

 Issue: National Resolve
 Impact: National Commitment increased through Displays & Illustrations and Education Enhanced
 Approach: Design and Fabricate Models
 Product: Models for illustrating technology improvements to the public

NLS Engineering Demonstration Initiative

Candidates - Strengthen Engineering Base & National Resolve

- Russian Hardware

Issue:	Engineering Base & National Resolve
Impact:	Endorsement of the Baseline; Confirmation of Design Criteria; and Assistance to Third World
Approach:	Acquire, blueprint, test existing Russian Hardware for potential application to NLS
Product:	Engineering Data and Hardware

Back-up

NLS Engineering Demonstration Initiative

Strengthen the Engineering Base ... consider

- RESOLVE KNOWN ENGINEERING ISSUES

 a. Engine Throttling
 b. Engine Out
 c. Engine Re-start
 d. Human Rating
 e. Recover/Refurbishment of hardware
 f. Ship and Shoot
 g. Pad Access

- PERFORM TRADE STUDIES TO

 a. Establish Alternative Concepts/Options
 b. Confirm Design Criteria
 c. Define Basic Operational Scenarios
 d. Confirm Performance Capabilities
 e. Verify Processing

- VERIFY THE BASELINE

NLS Engineering Demonstration Initiative

Strengthen the Programmatic Base ... consider

- SYSTEM(S) DEFINITION
 a. SRD
 b. TRD
 c. CEI
 d. ICD
 e. etc.

- PLANS AND STRATEGIES
 a. Acquisition
 b. Manufacturing
 c. Facilities
 d. Assembly
 e. Checkout
 f. Launch Processing

- MISSION AND APPLICATION DEFINITION
 a. Payload
 b. Operational Scenarios
 c. Performance Profiles
 d. Assured Access

NLS Engineering Demonstration Initiative

Strengthen the National Resolve ... consider

- FORMULATE STRONG NEED STATEMENT
 a. White House
 b. Congress
 c. NASA
 d. DOD
 e. Aerospace Industry
 f. User

- DEFINE THE BENEFITS/RETURN ON INVESTMENT
 a. Technology Advancement
 b. Leadership in Space
 c. Enhance Education
 d. Application to Life Style
 e. Assistance to Third World

- PROVIDE NATIONAL INCENTIVE(S)
 a. Return on Investments
 b. Tax Credits
 c. Commercial Use
 d. Cost sharing

- OBTAIN NATIONAL COMMITMENT
 a. 15 Year Funding Plan
 b. 10 Year funding commitment
 c. Modern Day Acquisition Process
 d. Definitive Objectives
 e. Displays/Illustrations

1.2.15 Engineering Demonstration Candidate

Task report 1.2.14 is the description of an engineering demonstration candidate, namely, the Avionics System Simulation. This report contains the rationale, description, estimated cost, and schedule for the expansion of the MSFC engine simulation laboratory, Building 4476; to embrace the entire National Launch System Avionics System.

Avionics System Simulation

NLS Engineering Demonstration Initiative

Avionics System Simulation - Expansion of the Engine Simulation Lab

Rationale

Expansion of the MSFC Engine Simulation Laboratory to embrace the entire NLS Avionics System would provide a means to optimize and verify avionics performance parameters. Also, high risk areas such as Fault Tolerance, Distributed Computing, Vehicle Health Management, and Software Development Prototyping could be explored and demonstrated, providing momentum for FSD. The long run benefits of the Lab would include: provision of a tool to use in evaluating proposed changes/additions to NLS and provision of a tool to use for training/education purposes.

System Description

1. Avionics System

 Figure 1 shows a simplified overview of the system. Portions of each of the items shown on Figure 1 are already in existence at the Engine Simulation Lab.

2. Engine Simulation Lab

 Figure 2 shows a simplified overview of the Lab. The Lab as it now exists is functional, but further expansion of it's capability, i.e., actuators, sensors, etc..., should be done in an overall expansion for an Avionics Simulation.

NLS Engineering Demonstration Initiative

Avionics System Simulation - Proposed

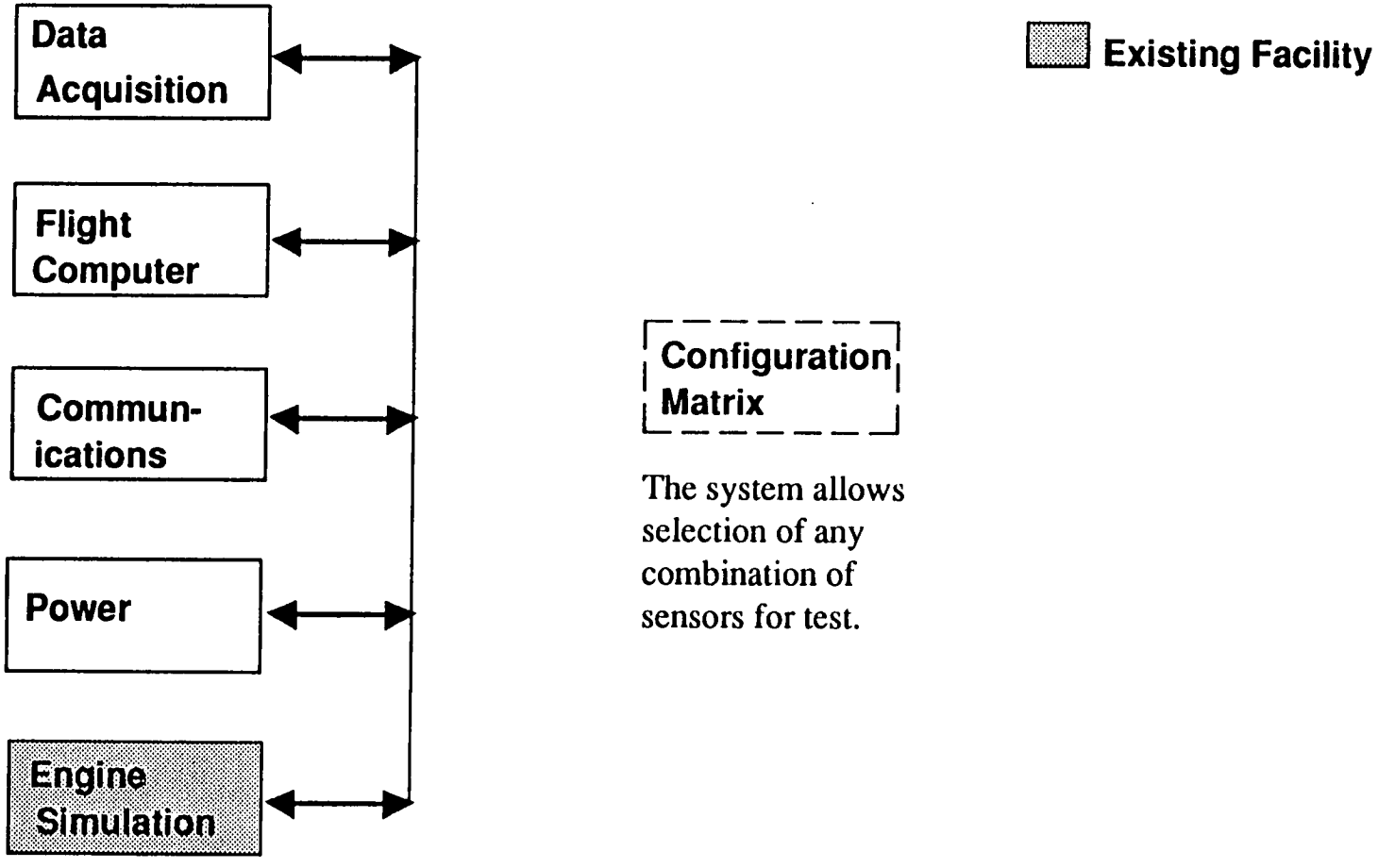


Figure 1

NLS Engineering Demonstration Initiative

Engine System Simulation - Existing

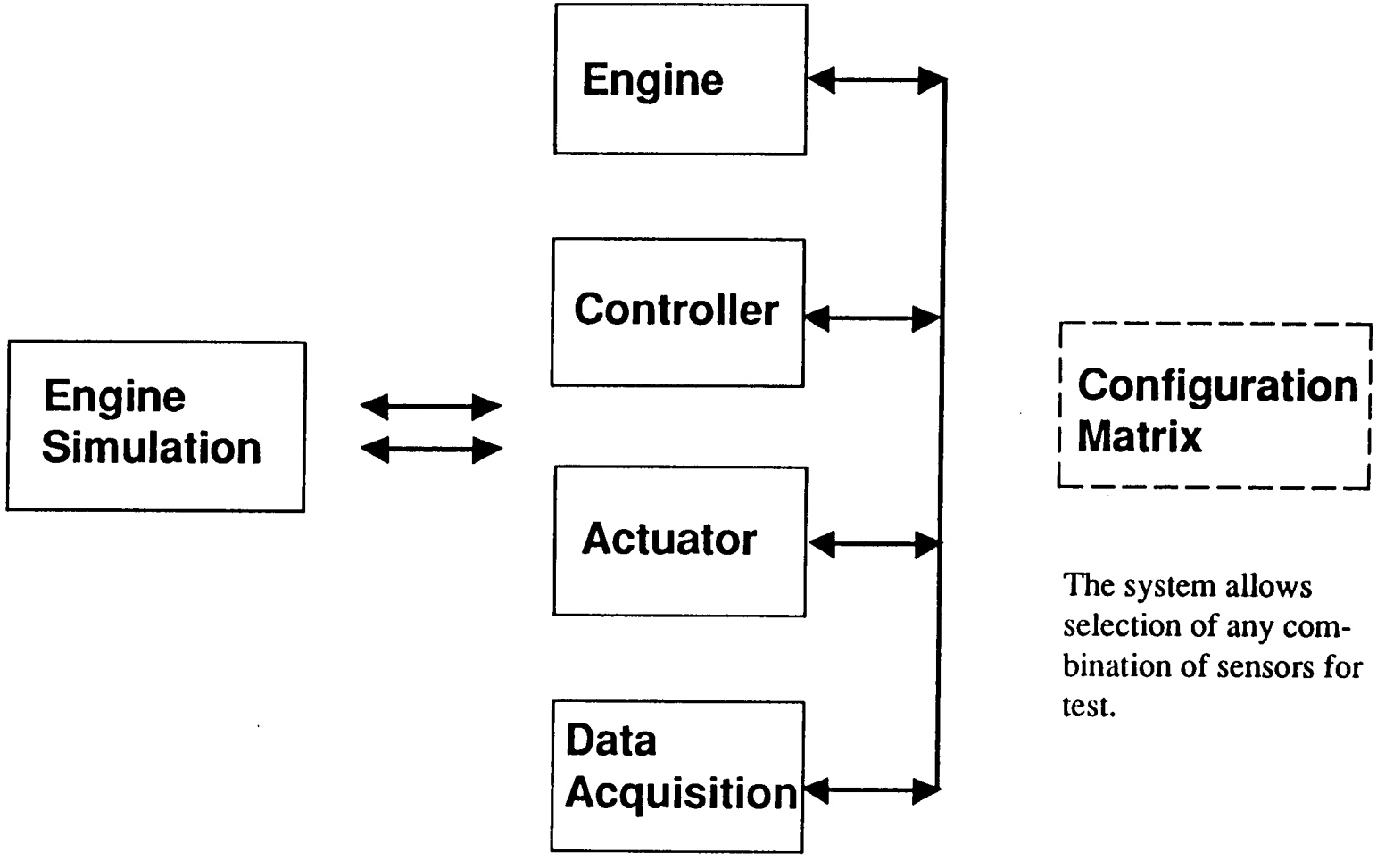


Figure 2

NLS Engineering Demonstration Initiative

Avionics System Simulation - Expansion of the Engine Simulation Lab

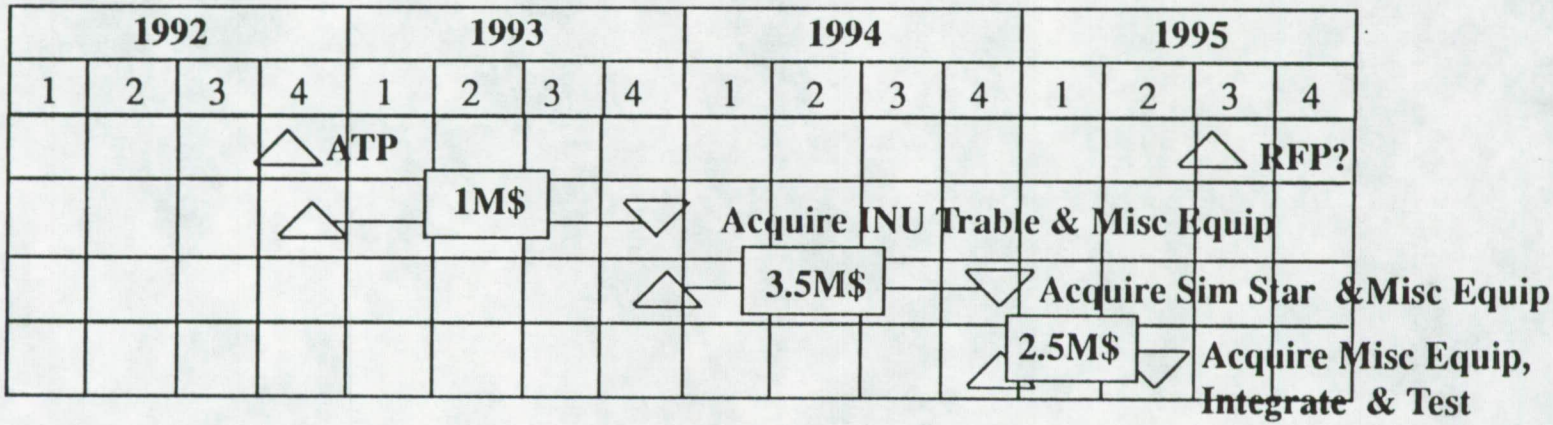
Cost Breakdown

Engine Simulation	$ 7.0M
Sim Star	2.0M
INU Table	.6M
Misc	4.4M

Exising Facility

Existing & Proposed	$14.0M
Proposed Expansion	**$ 7.0M over 2.5 Yrs**

Schedule



NLS Engineering Demonstration Initiative

Avionics System Simulation - Expansion of The Engine Simulation Lab

Summary/System Overview

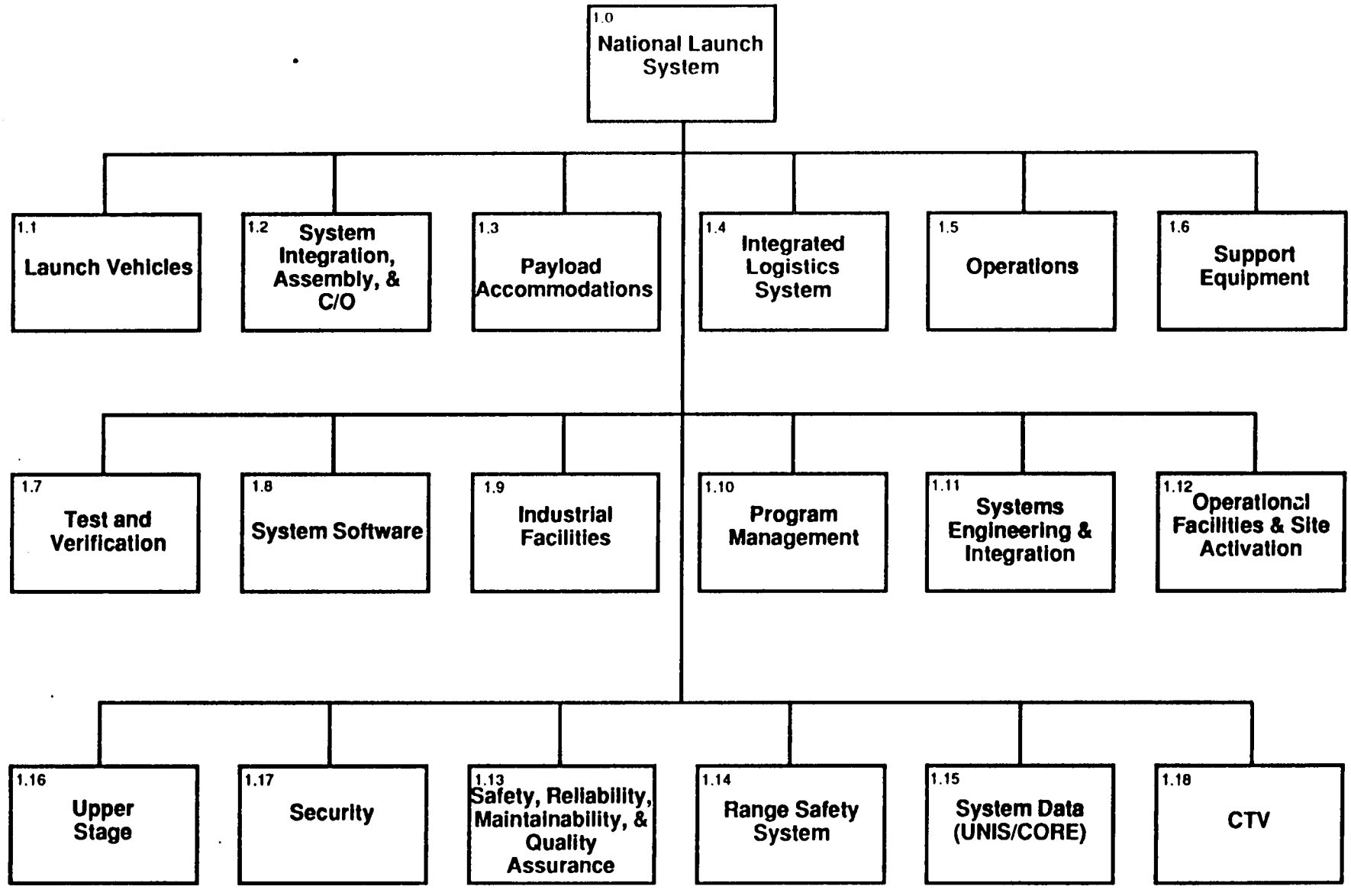
1. Issues Addressed:	NLS Avionics System
2. Impact To Program:	Optimization and verification of NLS Avionics Hardware and Software for different payloads and mission requirements. And, exploration and demonstration of high risk avionics areas.
3. Approach:	Expand the MSFC Engine Simulation Lab, Building #4476.
4. Schedule:	2 and 1/2 years to complete expansion, integrate, and test.
5. Cost:	$7M 1.0M in Year 1 3.5M in Year 2 2.5M in Year 3

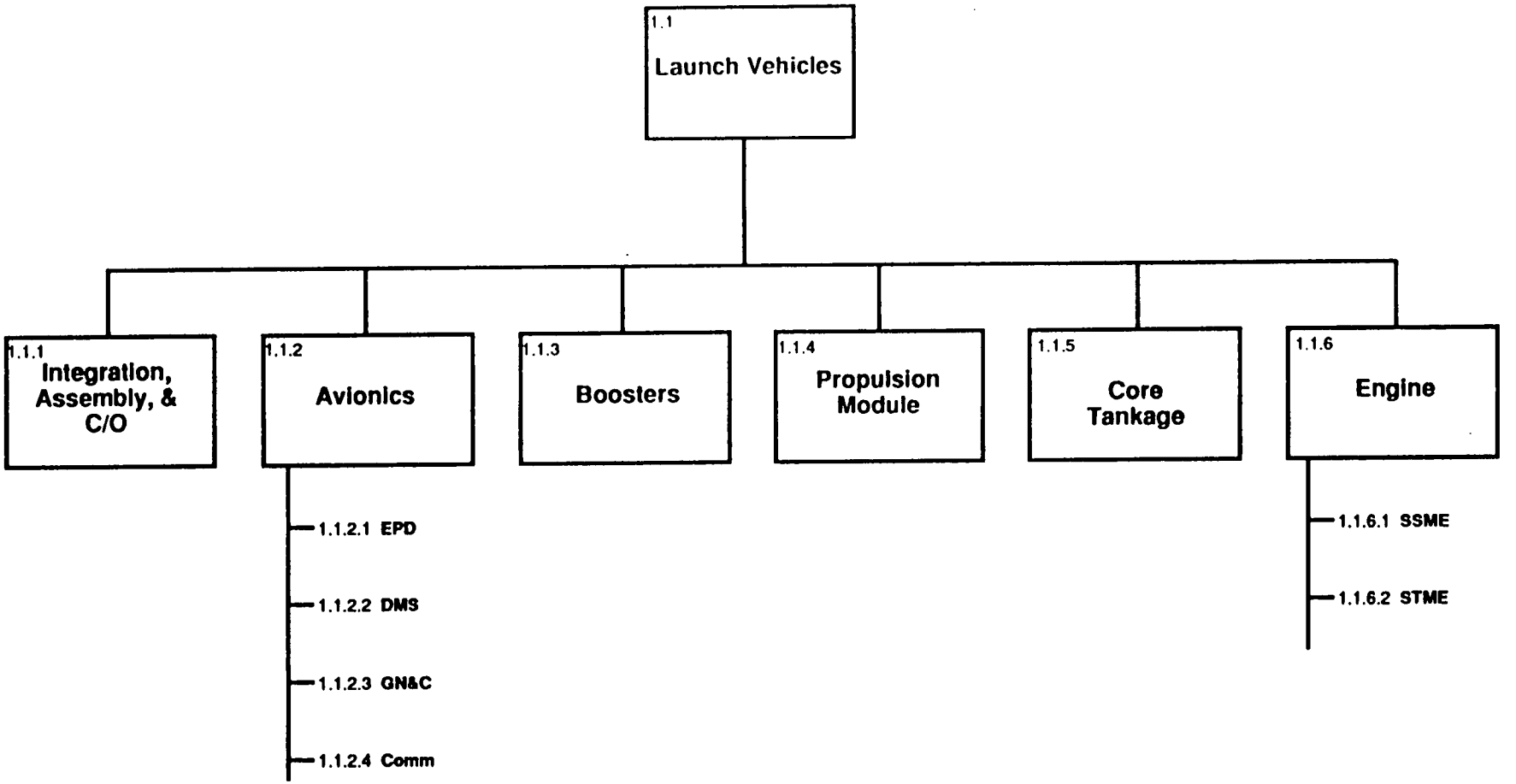
Concept	Factors	Investment Cost	Payback Period	Schedule	Eng/Cost Database	Vehicle Config/Perf/ Eng Issues	Manuf/Test/ Check-Out/ Ops Issues	Program-matic Base	Cost Impact (DDT & E)	Cost Impact (Cost/Flight)	Promotional Value	Total Score(A) 198	Total Score(B) 10
Avionics System Simulation	Rating	0	3	1	3	3	0	0	3	3	2		
	Weight	5	4	5	6	8	8	6	8	8	8		
	Score(A)	0	12	5	18	24	0	0	24	24	16	123.0	
	Score(B)	0.0	0.6	0.3	0.9	1.2	0.0	0.0	1.2	1.2	0.8		6.2

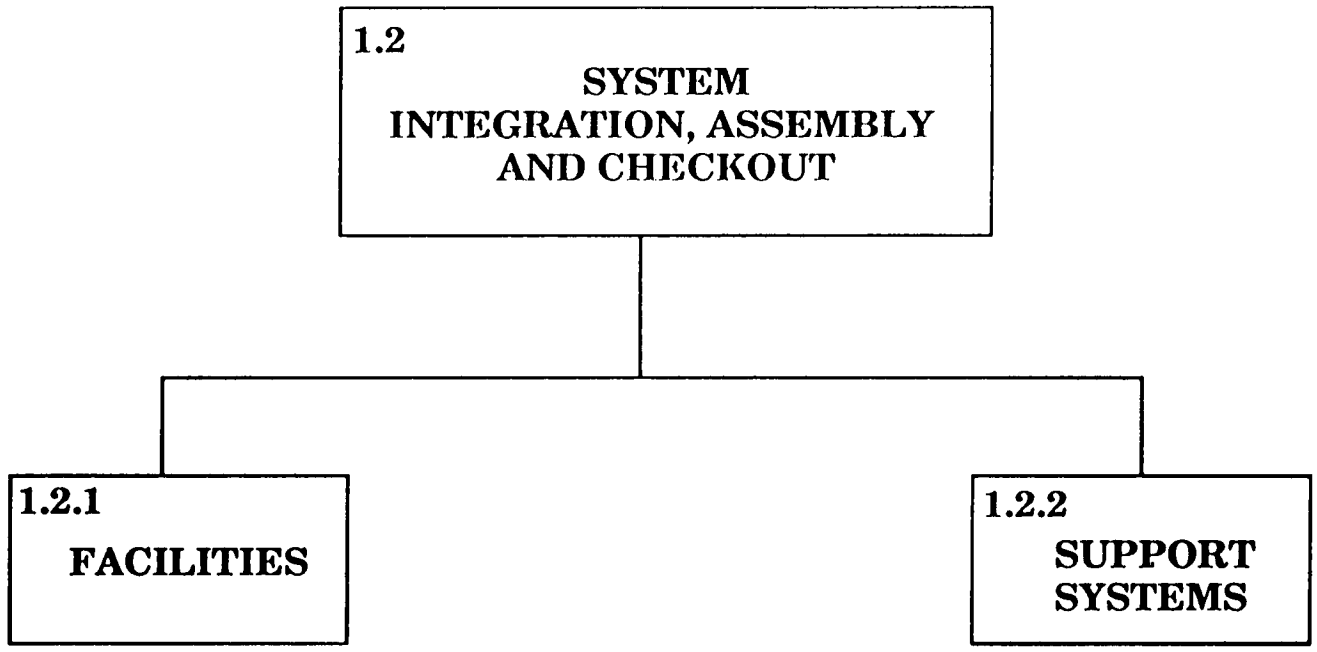
1.2.16 WBS Review and Comments

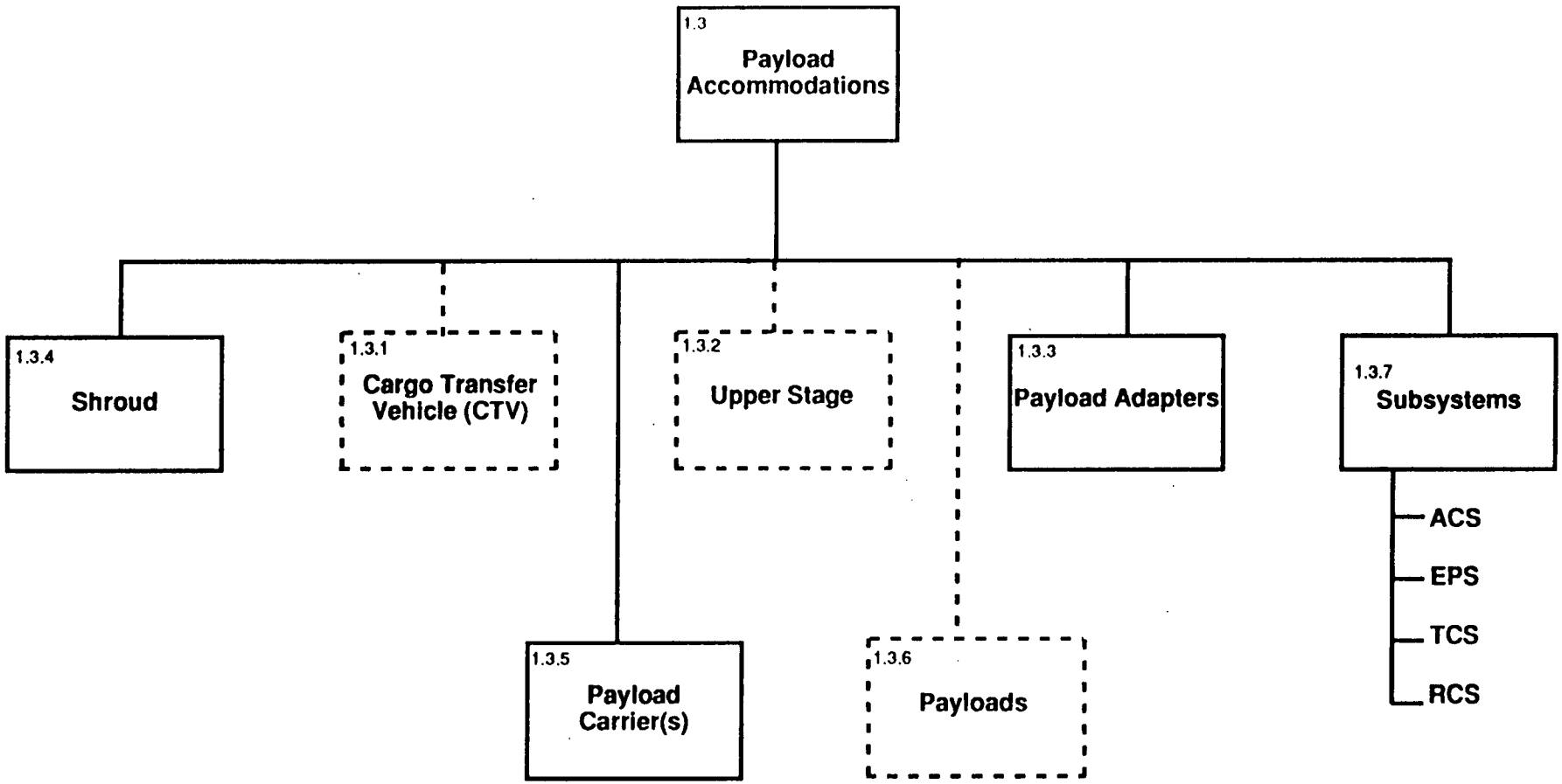
Task report 1.2.16 is a USBI version of a National Launch System work breakdown structure (WBS) and a WBS dictionary.

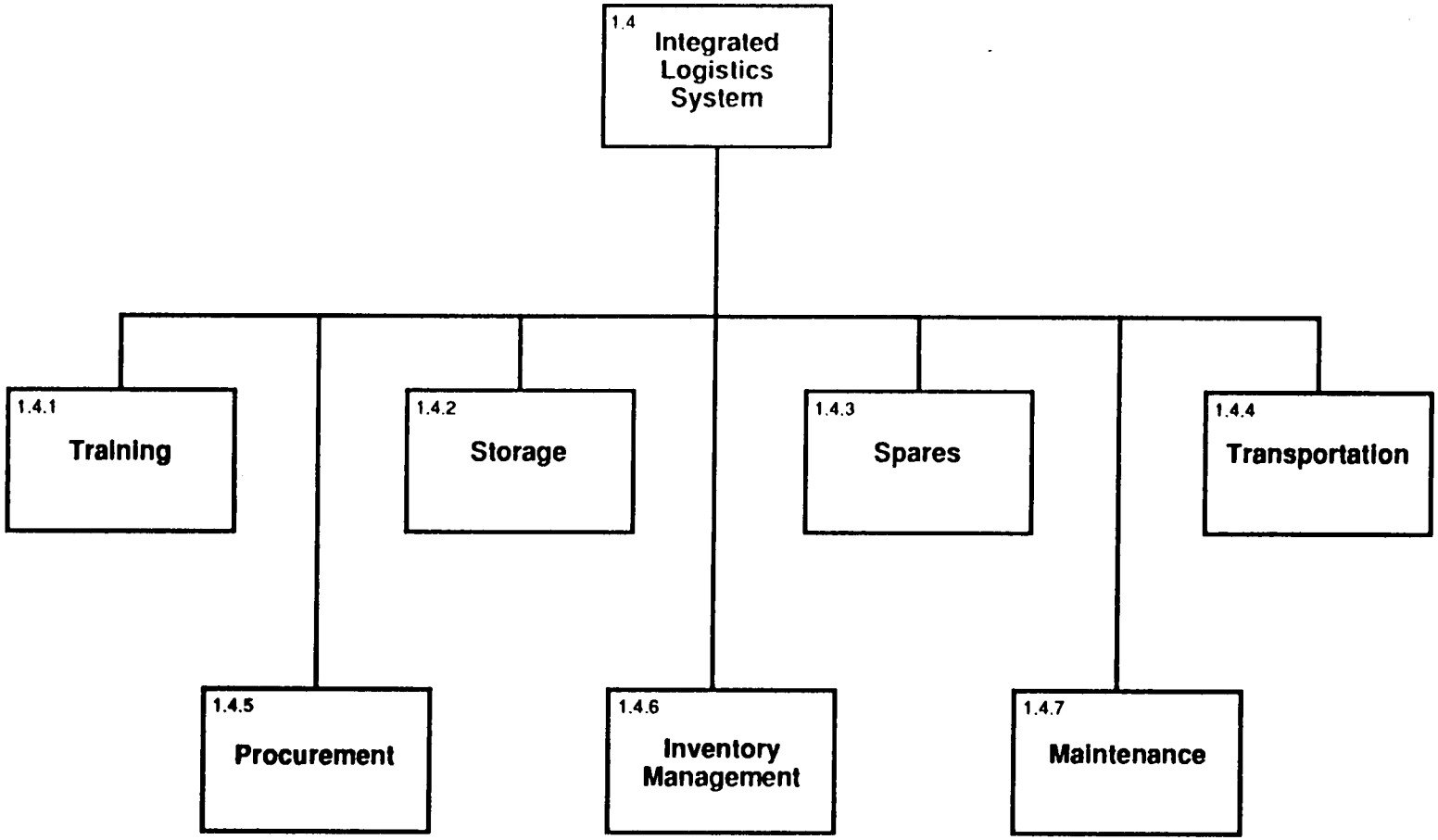
National Launch System WBS - USBI

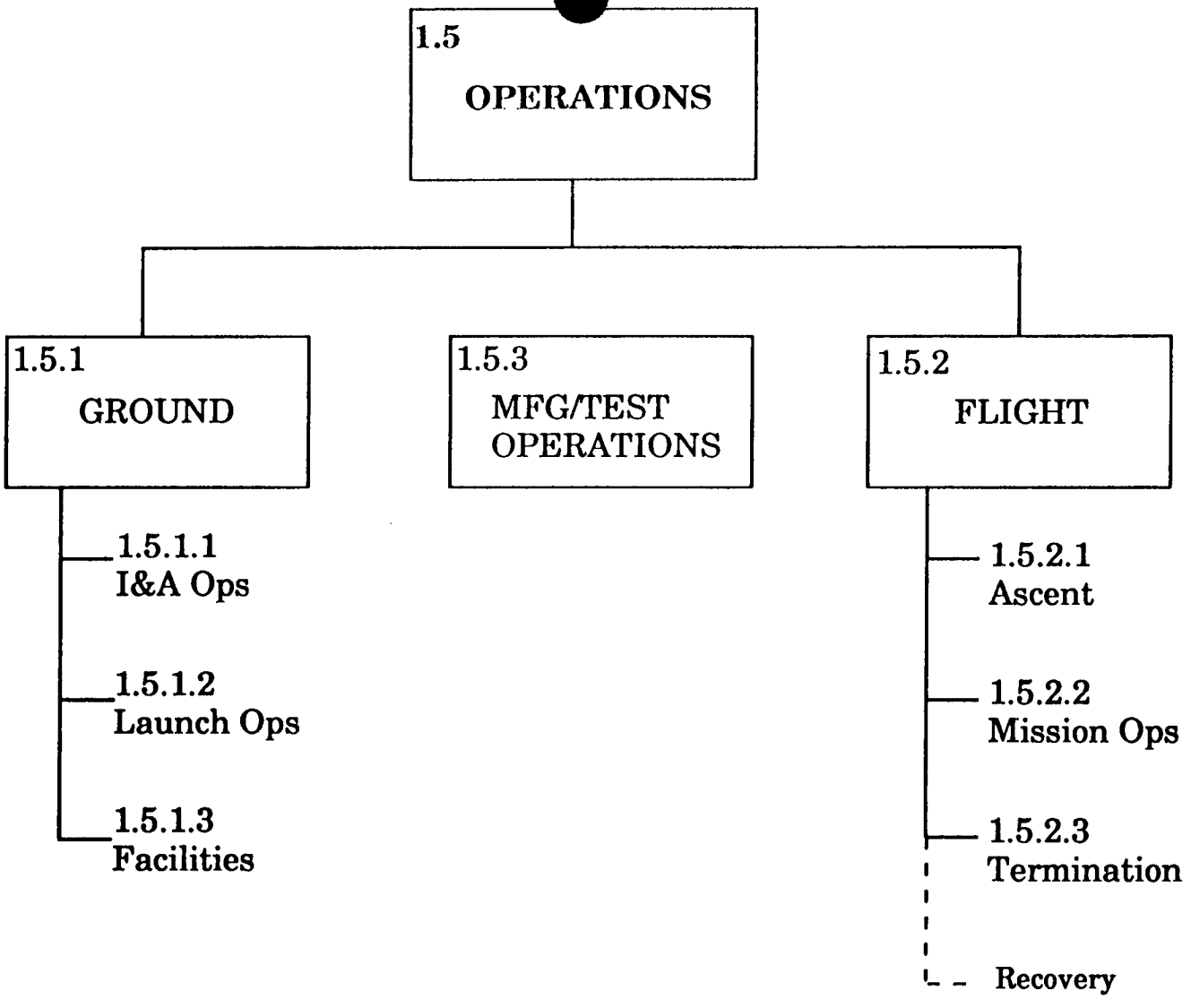


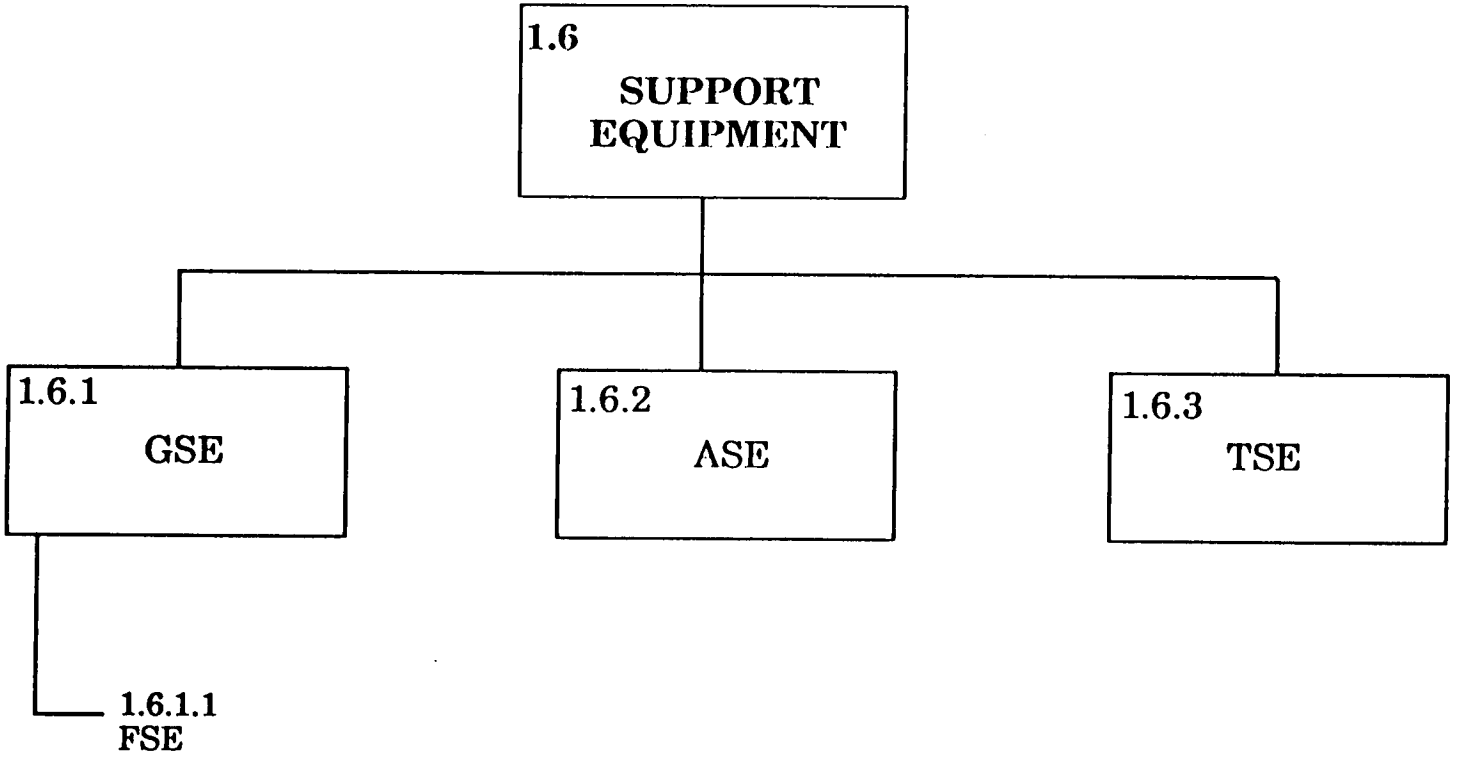

1.1
Launch Vehicles
1.1.1
Integration, Assembly, & C/O
1.1.2
Avionics
1.1.3
Boosters
1.1.4
Propulsion Module
1.1.5
Core Tankage
1.1.6
Engine
1.1.2.1 EPD
1.1.2.2 DMS
1.1.2.3 GN&C
1.1.2.4 Comm
1.1.6.1 SSME
1.1.6.2 STME

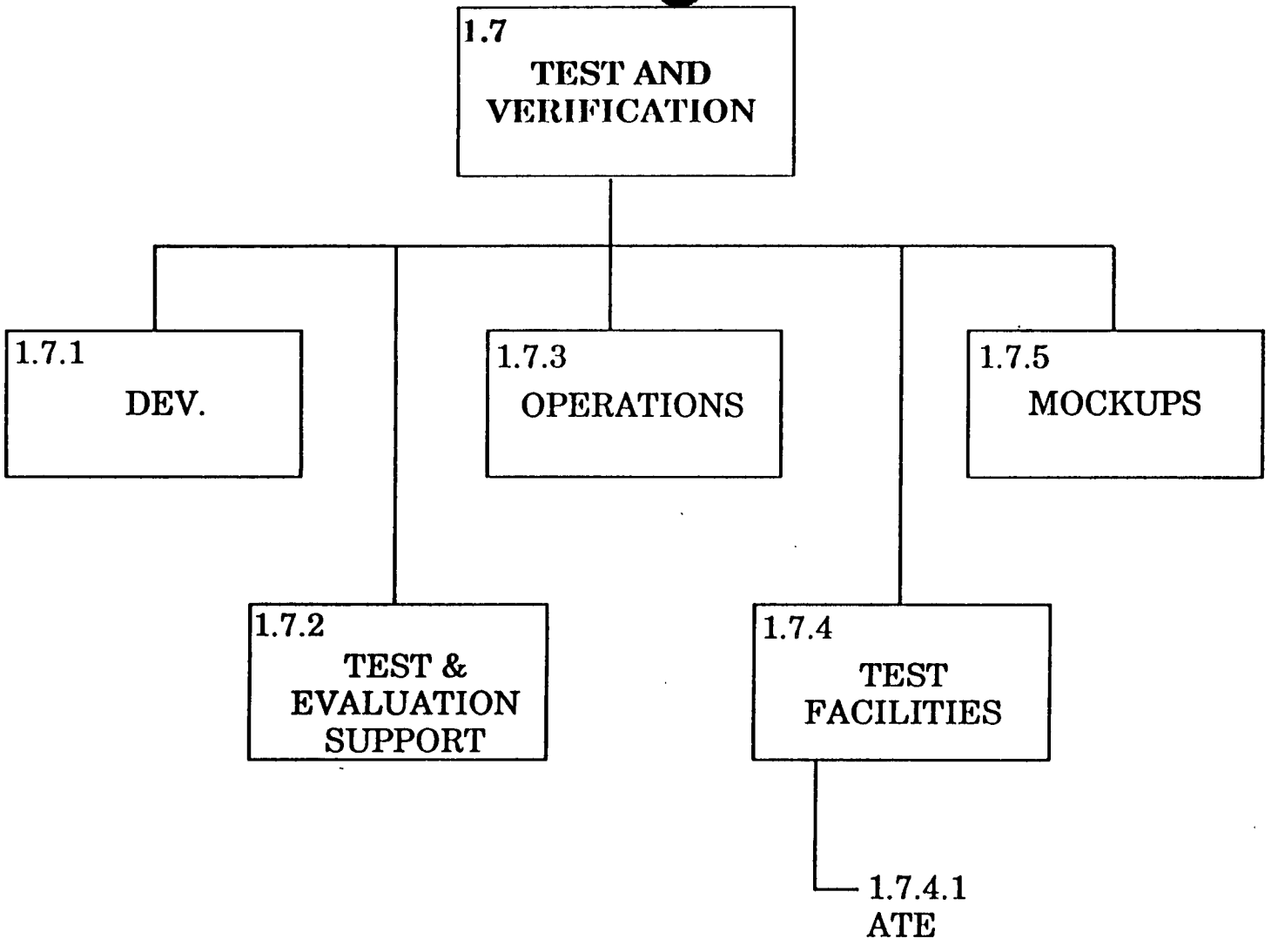

1.2
SYSTEM
INTEGRATION, ASSEMBLY
AND CHECKOUT
1.2.1
FACILITIES
1.2.2
SUPPORT
SYSTEMS

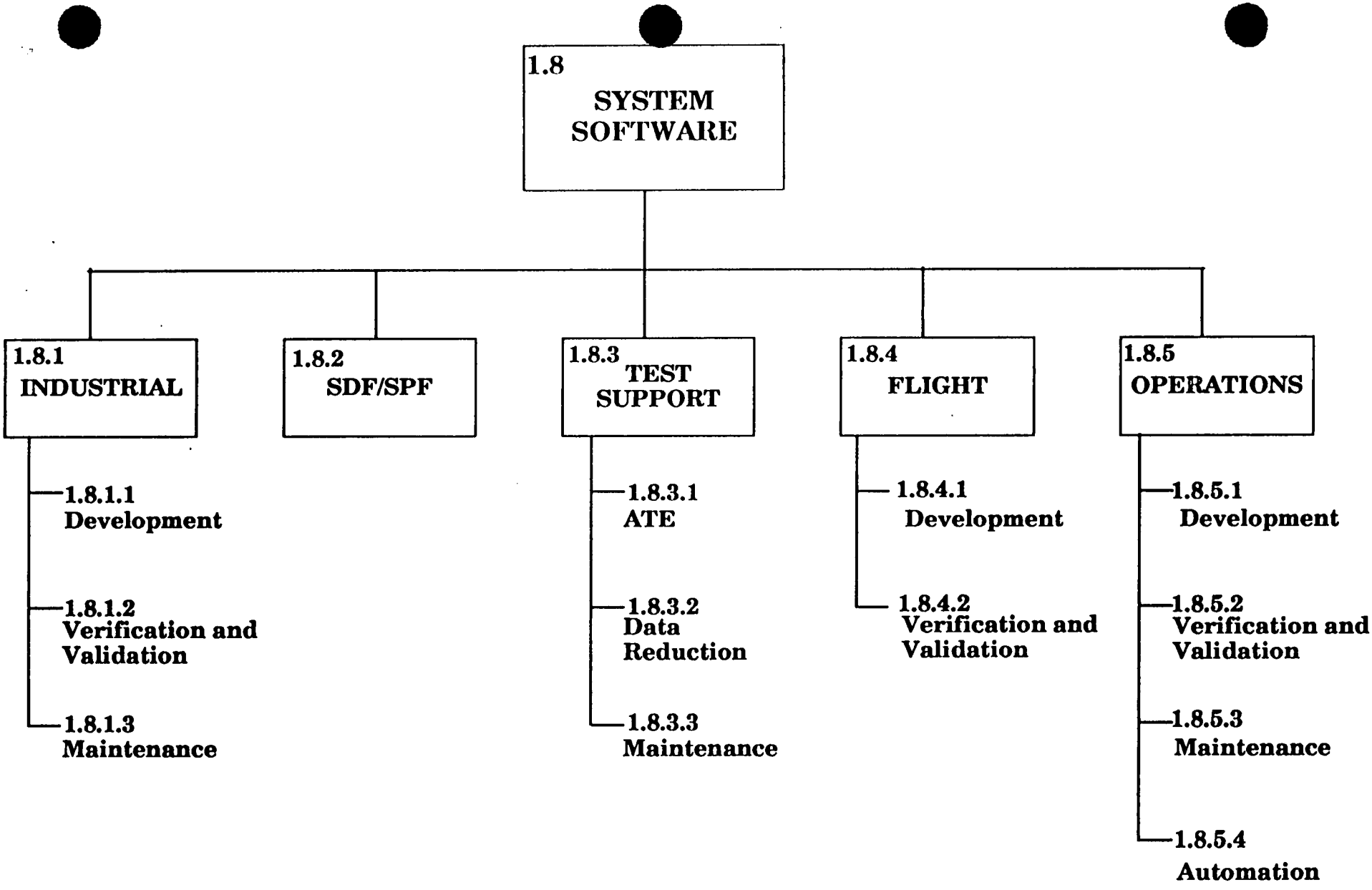

1.3
Payload Accommodations
1.3.4
Shroud
1.3.1
Cargo Transfer Vehicle (CTV)
1.3.2
Upper Stage
1.3.3
Payload Adapters
1.3.7
Subsystems
ACS
EPS
TCS
RCS
1.3.5
Payload Carrier(s)
1.3.6
Payloads


1.4
Integrated Logistics System
1.4.1
Training
1.4.2
Storage
1.4.3
Spares
1.4.4
Transportation
1.4.5
Procurement
1.4.6
Inventory Management
1.4.7
Maintenance

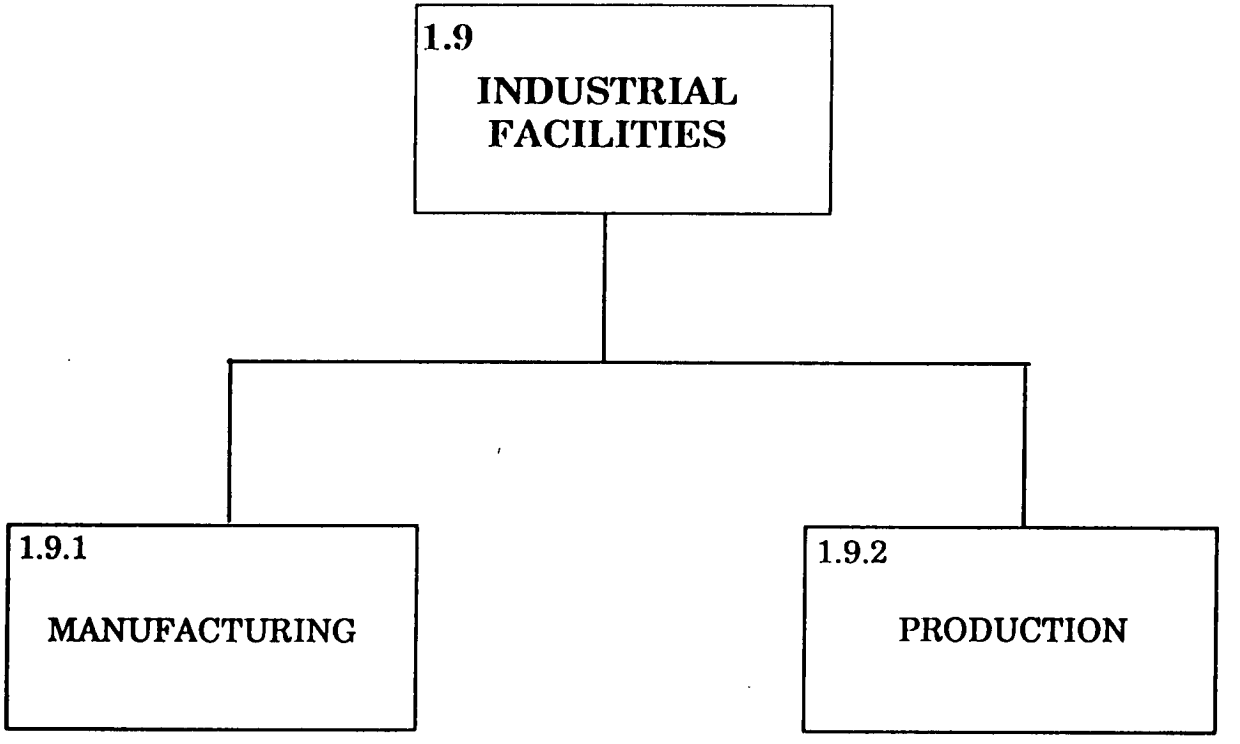

1.5
OPERATIONS
1.5.1
GROUND
1.5.3
MFG/TEST
OPERATIONS
1.5.2
FLIGHT
1.5.1.1
I&A Ops
1.5.1.2
Launch Ops
1.5.1.3
Facilities
1.5.2.1
Ascent
1.5.2.2
Mission Ops
1.5.2.3
Termination
Recovery

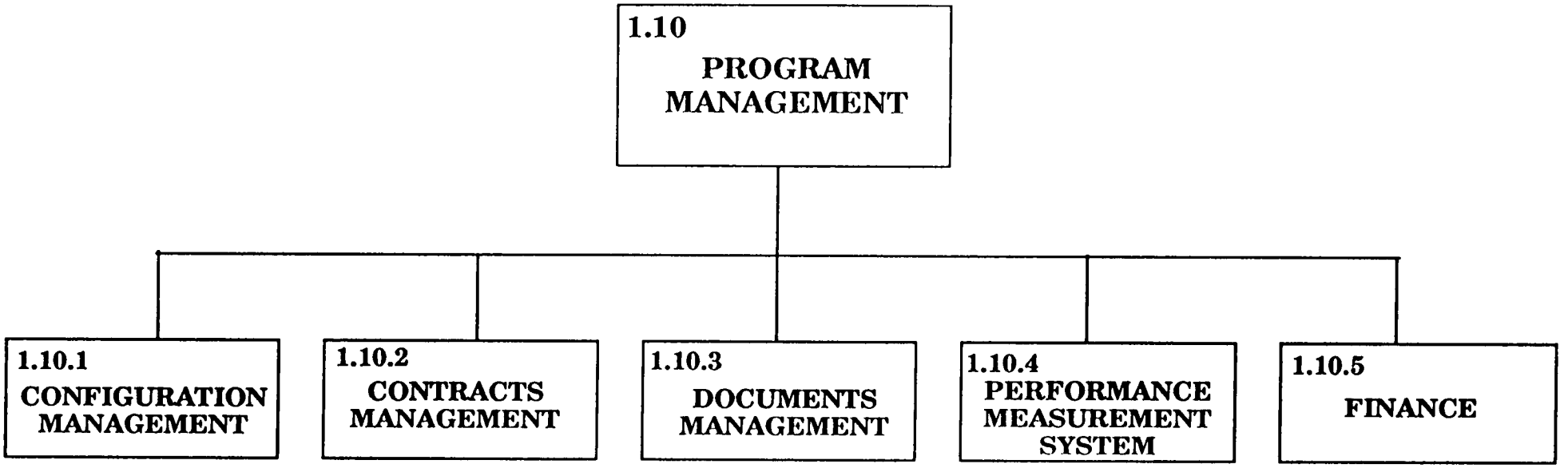

1.6
SUPPORT EQUIPMENT
1.6.1
GSE
1.6.2
ASE
1.6.3
TSE
1.6.1.1
FSE

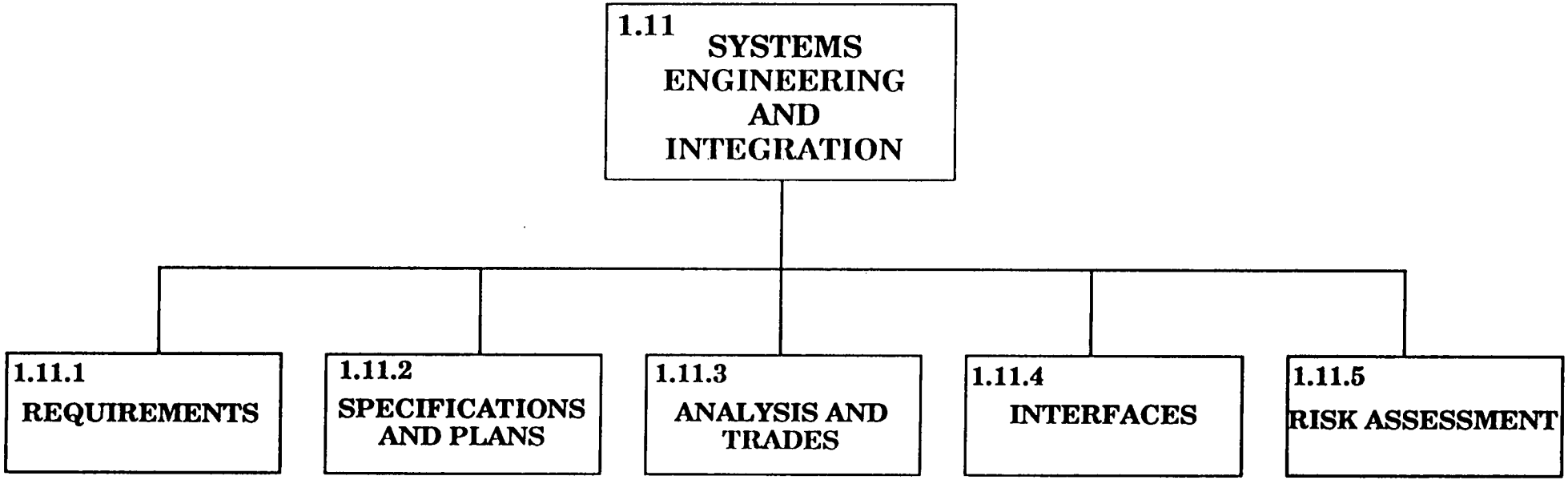

1.7
TEST AND VERIFICATION
1.7.1
DEV.
1.7.3
OPERATIONS
1.7.5
MOCKUPS
1.7.2
TEST & EVALUATION SUPPORT
1.7.4
TEST FACILITIES
1.7.4.1
ATE

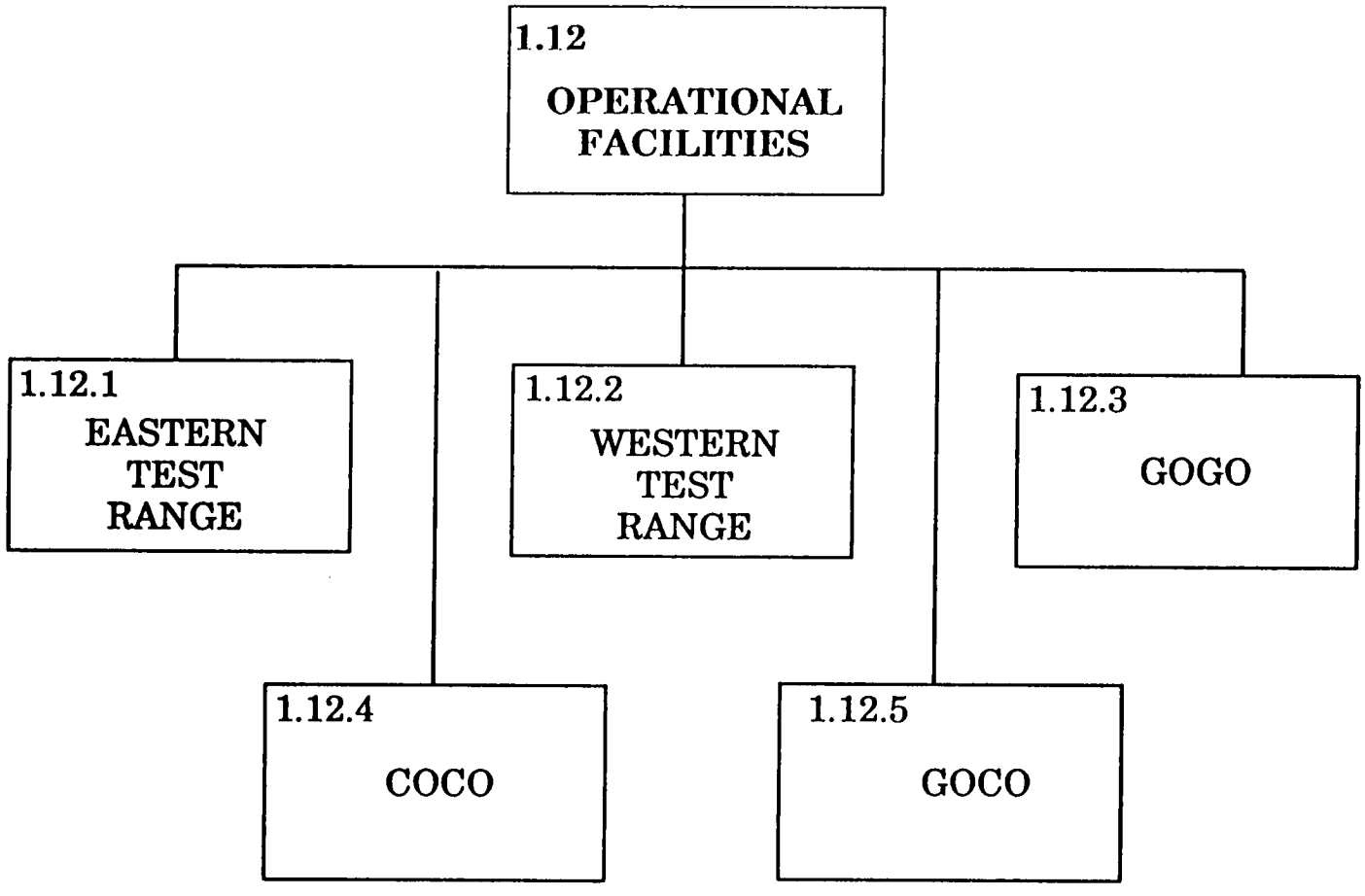

1.8
SYSTEM SOFTWARE
1.8.1
INDUSTRIAL
1.8.2
SDF/SPF
1.8.3
TEST SUPPORT
1.8.4
FLIGHT
1.8.5
OPERATIONS
1.8.1.1
Development
1.8.1.2
Verification and Validation
1.8.1.3
Maintenance
1.8.3.1
ATE
1.8.3.2
Data Reduction
1.8.3.3
Maintenance
1.8.4.1
Development
1.8.4.2
Verification and Validation
1.8.5.1
Development
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Verification and Validation
1.8.5.3
Maintenance
1.8.5.4
Automation

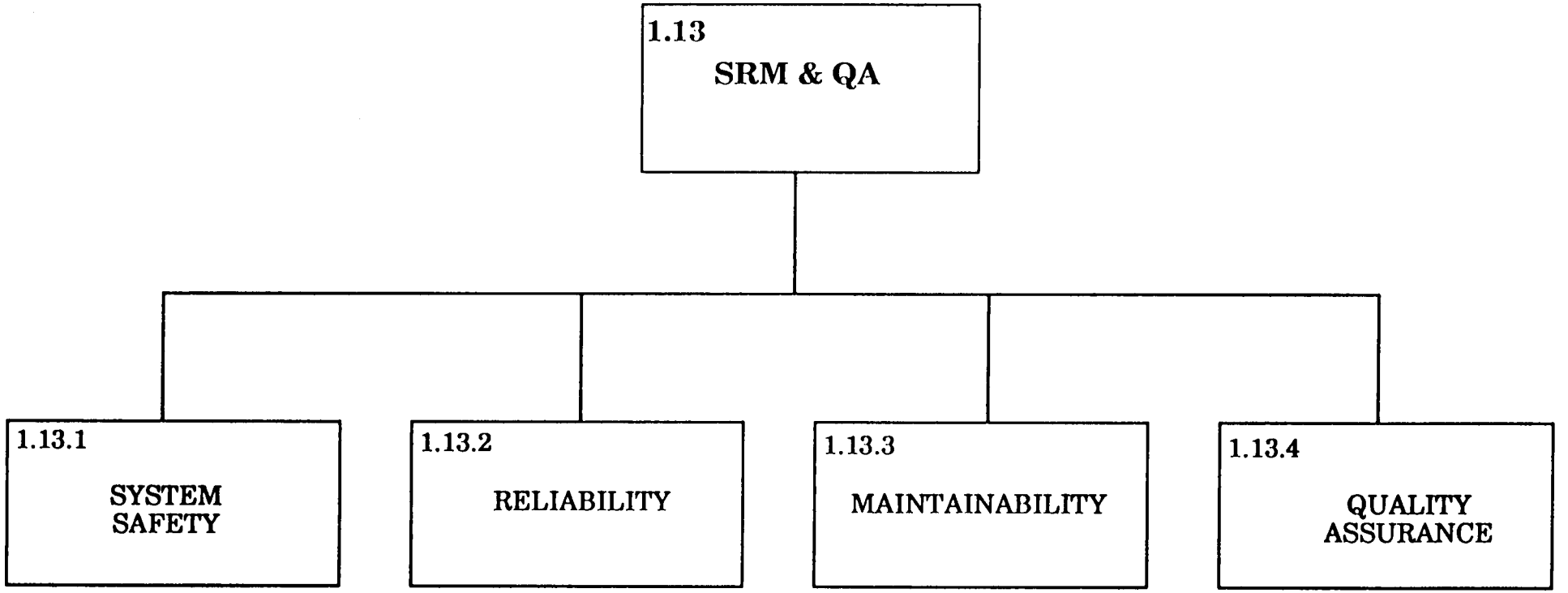
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1.9
INDUSTRIAL FACILITIES
1.9.1
MANUFACTURING
1.9.2
PRODUCTION

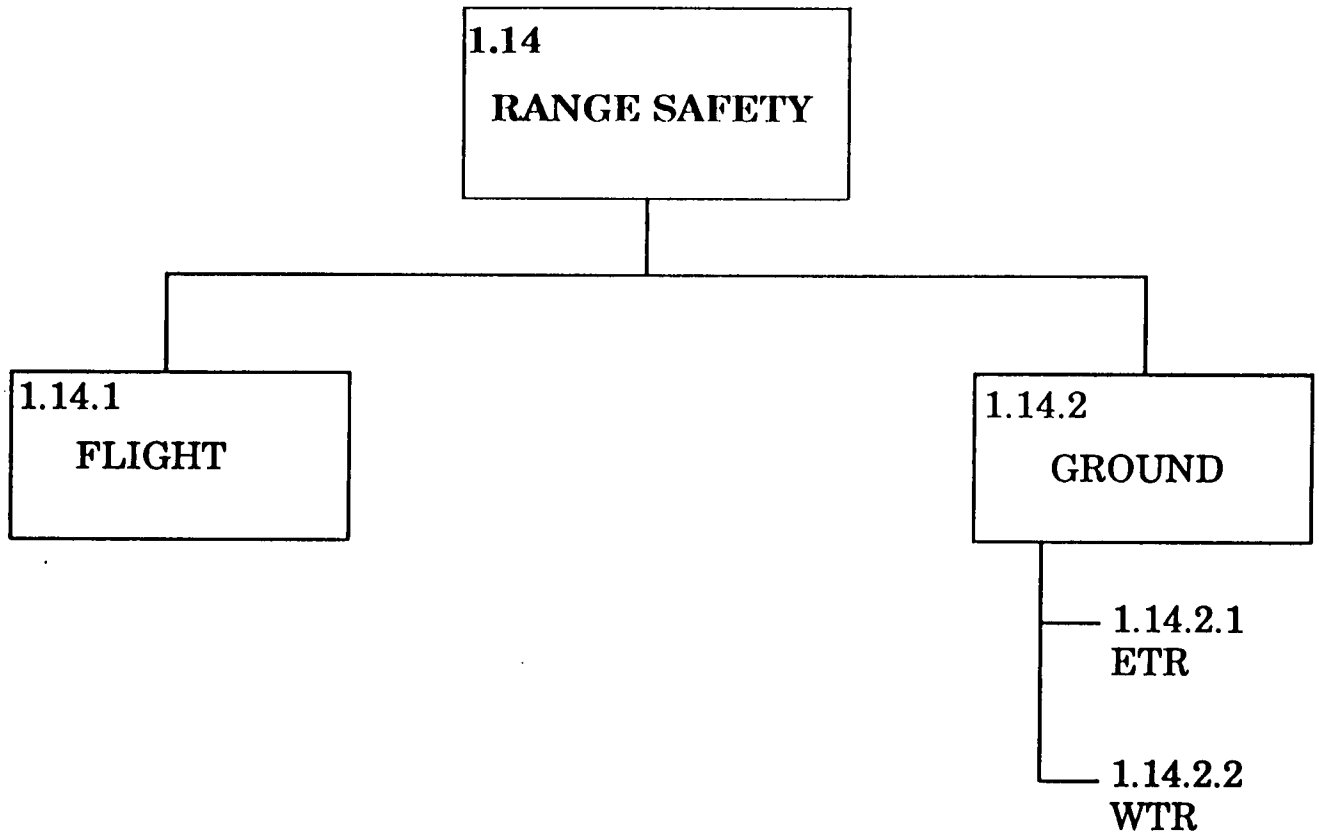

1.10
PROGRAM MANAGEMENT
1.10.1
CONFIGURATION MANAGEMENT
1.10.2
CONTRACTS MANAGEMENT
1.10.3
DOCUMENTS MANAGEMENT
1.10.4
PERFORMANCE MEASUREMENT SYSTEM
1.10.5
FINANCE


1.11
SYSTEMS ENGINEERING AND INTEGRATION
1.11.1
REQUIREMENTS
1.11.2
SPECIFICATIONS AND PLANS
1.11.3
ANALYSIS AND TRADES
1.11.4
INTERFACES
1.11.5
RISK ASSESSMENT

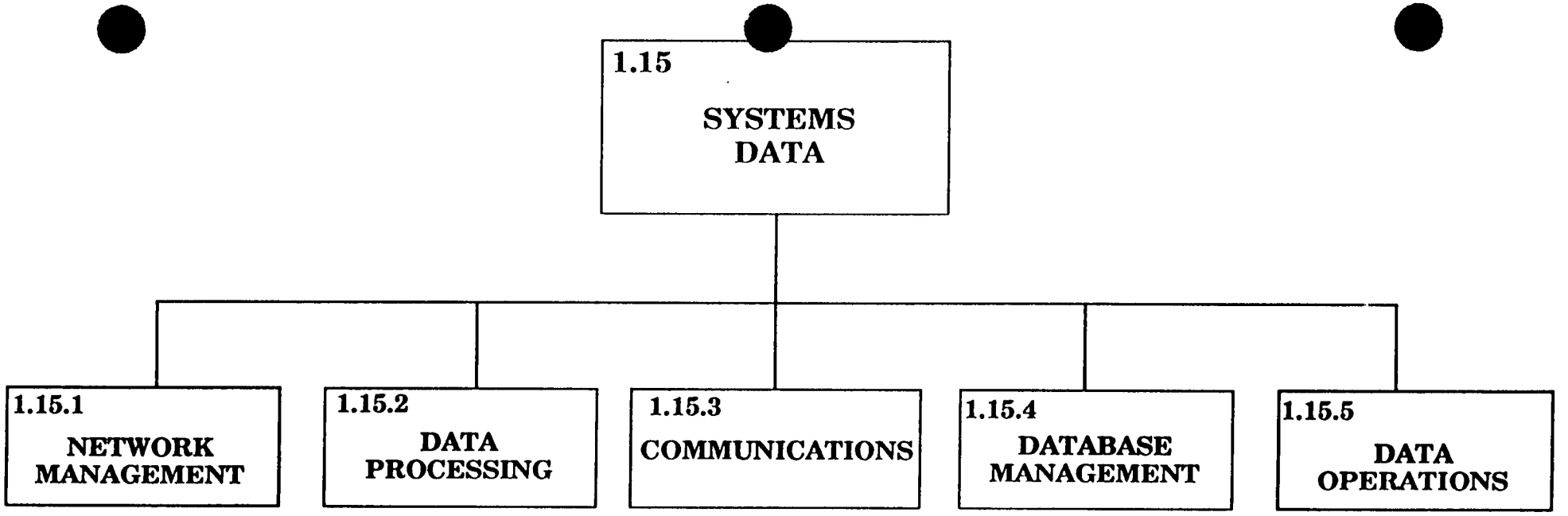

1.12
OPERATIONAL FACILITIES
1.12.1
EASTERN TEST RANGE
1.12.2
WESTERN TEST RANGE
1.12.3
GOGO
1.12.4
COCO
1.12.5
GOCO


1.13
SRM & QA
1.13.1
SYSTEM SAFETY
1.13.2
RELIABILITY
1.13.3
MAINTAINABILITY
1.13.4
QUALITY ASSURANCE

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1.14
RANGE SAFETY
1.14.1
FLIGHT
1.14.2
GROUND
1.14.2.1
ETR
1.14.2.2
WTR

113995


1.15
SYSTEMS DATA
1.15.1
NETWORK MANAGEMENT
1.15.2
DATA PROCESSING
1.15.3
COMMUNICATIONS
1.15.4
DATABASE MANAGEMENT
1.15.5
DATA OPERATIONS

National Launch System
Work Breakdown Structure Dictionary

Rev. 2, 4/29/91, MAP

1.0 National Launch System

- Refers to the material, effort, and facilities necessary to meet the U.S. requirements for an operational capability in space. Operational capability is defined in terms of the ability to place, maintain, and deorbit mission payloads in their specified environments.
- Consists of all program phases including full-scale development and operational activities. Within the full-scale development phase, this element covers all DDT&E efforts. Within the operational phase, this element covers all mission phases including assembly & check-out, transportation, ground processing, pre-launch, lift-off, ascent, separation events, on-orbit, reentry, and recovery/refurbishment (where required).
- This is the Level 1 WBS element which is comprehensive in nature and is comprised of the following Level 2 WBS elements.

1.1 Launch Vehicle

- Refers to the material, effort, and facilities necessary to develop and produce a system which will provide the initial thrust for placing mission payloads into their operational environments.
- Includes all the necessary engineering activities such as analysis (performance, laods, controls, etc.) and design (structures, mechanisms, subsystems, etc.) required to define and produce the integral components comprising the launch vehicle.

1.1.1 Integration, Assembly, and Check-Out
1.1.2 Avionics
1.1.2.1 Electrical Power and Distribution
1.1.2.2 Data Management System
1.1.2.3 Guidance, Navigation, and Control
1.1.2.4 Communications
1.1.2.5 Instrumentation
1.1.3 Boosters
1.1.4 Propulsion Module

1.1.5 Core Tankage
1.1.6 Engine
1.1.6.1 Space Shuttle Main Engine
1.1.6.2 Space Transportation Main Engine

1.2 System Integration, Assembly, and Check-Out

- Refers to the material, effort and facilities required to interface WBS Level 2 Elements into a complete launch system and then verify the integrity of the total unit.
- Includes electrical and mechanical interfaces, inter-vehicle structure, adapters, umbilicals, cables, and connectors.

1.2.1 Facilities
1.2.2 Support Systems

1.3 Payload Accommodations

- Refers to the effort and hardware required to allow payloads, as defined in the NLS mission model, to be incorporated into the system in order to achieve their desired operational capability.
- Includes the structural, mechanical, electrical, and software capabilities required by the user payloads.

1.3.1 Cargo Transfer Vehicle (CTV)
1.3.2 Upper Stage
1.3.3 Payload Adapter
1.3.4 Shroud
1.3.5 Payload Carrier(s)
1.3.6 Payloads
1.3.7 Subsystems
1.3.7.1 APS
1.3.7.2 EPS
1.3.7.3 TCS
1.3.7.4 RCS

1.4 Integrated Logistics System

- Refers to the effort and materials required to support the procurement, maintenance, distribution, and replacement of personnel and material for the NLS.
- Includes both the initial activity required to define the operational procedures comprising the system and the on-going effort which implements the procedures during the program operational phase.

1.4.1 Training
1.4.2 Storage
1.4.3 Spares
1.4.4 Transportation
1.4.5 Procurement
1.4.6 Inventory Management
1.4.7 Maintenance

1.5 Operations

- Refers to the effort, materials, and facilities required to process, launch, and provide flight support for NLS components and payloads.
- Includes the mission phases from vehicle and payload hardware arrival at the launch complex through reentry and recovery/refurbishment (where required) of all components which are under the responsibility of the NLS program.

1.5.1 Ground
 1.5.1.1 Integration and Assembly Operations
 1.5.1.2 Launch Operations
 1.5.1.3 Facilities
1.5.2 Flight
 1.5.2.1 Ascent
 1.5.2.2 Mission Ops
 1.5.2.3 Termination

1.6 Support Equipment

- Refers to those items required to assist the NLS in performance of its mission but which are not an integral component of the flight system.

- Includes all of the material and effort necessary for the design, development, production, integration, assembly, and test of the support equipment required by the NLS during its primary mission phases.

1.6.1 Ground Support Equipment
1.6.1.1 Facilities Support Equipment
1.6.2 Airborne Support Equipment
1.6.3 Test Support Equipment

1.7 Test and Verification

- Refers to the effort, hardware, and facilities utilized to obtain or validate engineering data on the performance of the NLS.
- Includes the detailed planning, test conduction, test support, data reduction, data evaluation, and documentation. Also includes the design and production of models, specimens, fixtures, and instrumentation in support of obtaining the engineering data.

1.7.1 Development
1.7.2 Test & Evaluation Support
1.7.3 Operations
1.7.4 Test Facilities
1.7.4.1 Automated Test Equipment
1.7.5 Mockups

1.8 System Software

- Refers to the effort, hardware, and facilities required to generate, verify, and maintain the software to be employed for all aspects of the NLS program.
- Includes all phases of software development and maintenance such as requirements definition, requirements allocation, preliminary design, detailed design, source code generation, and verification and validation.

1.8.1 Industrial
1.8.1.1 Development
1.8.1.2 Verification & Validation
1.8.1.3 Maintenance
1.8.2 SDF/SPF

1.8.3 Test Support
1.8.3.1 ATE
1.8.3.2 Data Reduction
1.8.3.3 Maintenance
1.8.4 Flight
1.8.4.1 Development
1.8.4.2 Verification & Validation
1.8.5 Operations
1.8.5.1 Development
1.8.5.2 Verification & Validation
1.8.5.3 Maintenance
1.8.5.4 Automation

1.9 Industrial Facilities

- Refers to the construction, conversion, or expansion of system-unique facilities for manufacturing and production.
- Includes facility construction, equipment acquisition, equipment modernization, and maintenance of these items.

1.9.1 Manufacturing
1.9.2 Production

1.10 Program Management

- Refers to the integration of the NLS activities from the business and administrative perspective in order to accomplish overall project objectives.
- Includes planning, organizing, directing, coordinating, integrating, and controlling, and is applicable through all system phases.

1.10.1 Configuration Management
1.10.2 Contracts Management
1.10.3 Documents Management
1.10.4 Performance Measurement System
1.10.5 Finance

1.11 Systems Engineering & Integration

- Refers to the technical efforts required to ensure a totally integrated program engineering effort.
- Includes the technical planning, directing, and coordinating of engineering activities throughout all program phases.

1.11.1 Requirements
1.11.2 Specifications & Plans
1.11.3 Analysis & Trades
1.11.4 Interfaces
1.11.5 Risk Assessment

1.12 Operational Facilities and Site Activation

- Refers to the real estate, construction, and conversion of site, utilities, and equipment to provide all unique facilities required to house, service, and launch a transportation system during the program operational phase.
- Includes system assembly, check-out, and installation into the site facility of permanently installed equipment which are unique to support of the program operational phase.

1.12.1 Eastern Test Range
1.12.2 Western Test Range
1.12.3 GOGO
1.12.4 COCO
1.12.5 GOCO

1.13 Safety, Reliability, Maintainability, and Quality Assurance

- Refers to the effort and materials required to ensure appropriate operational are developed and implemented which allow the NLS to meet applicable Government SRM & QA specifications.
- Includes both the initial activity required to define the operational procedures comprising the system and the on-going effort which implements the procedures during the program operational phase.

1.13.1 System Safety
1.13.2 Reliability

1.13.3 Maintainability
1.13.4 Quality Assurance

1.14 Range Safety System

- Refers to the effort, materials, and facilities required to ensure the safety of personnel, facilities, etc. during the mission phases of the NLS program while the vehicle is on or operating from the launch complex.
- Includes the planning and implementation of a comprehensive operational procedure for ensuring NLS compliance with Government specifications.

1.14.1 Flight
1.14.2 Ground
1.14.2.1 ETR
1.14.2.2 WTR

1.15 System Data (UNIS/CORE)

- Refers to the material and effort required to manage the data generated and maintained for the NLS.
- Includes only the material and effort required after a document or data package has been initially produced.

1.15.1 Network Management
1.15.2 Data Processing
1.15.3 Communications
1.15.4 Database Management
1.15.5 Data Operations

1.16 Upper Stage

- Refers to the material, effort, and facilities necessary to develop and produce a separate propulsive element (separate from the launch vehicle) used, as required, to place mission payloads into their final operational environment.
- Includes the structure, propulsion, controls, instrumentation, separation subsystems, and other equipment integral to the elements.
- The interface of this element to the launch vehicle is carried under the Payload Accommodations WBS Element.

1.17 Security

- Refers to the effort, materials, and facilities required to ensure the classification and physical integrity of all aspects of the NLS program.
- Includes data storage, documentation, communications, and payload integration and covers all aplicable mission phases, i.e., launch processing, flight operations, etc.

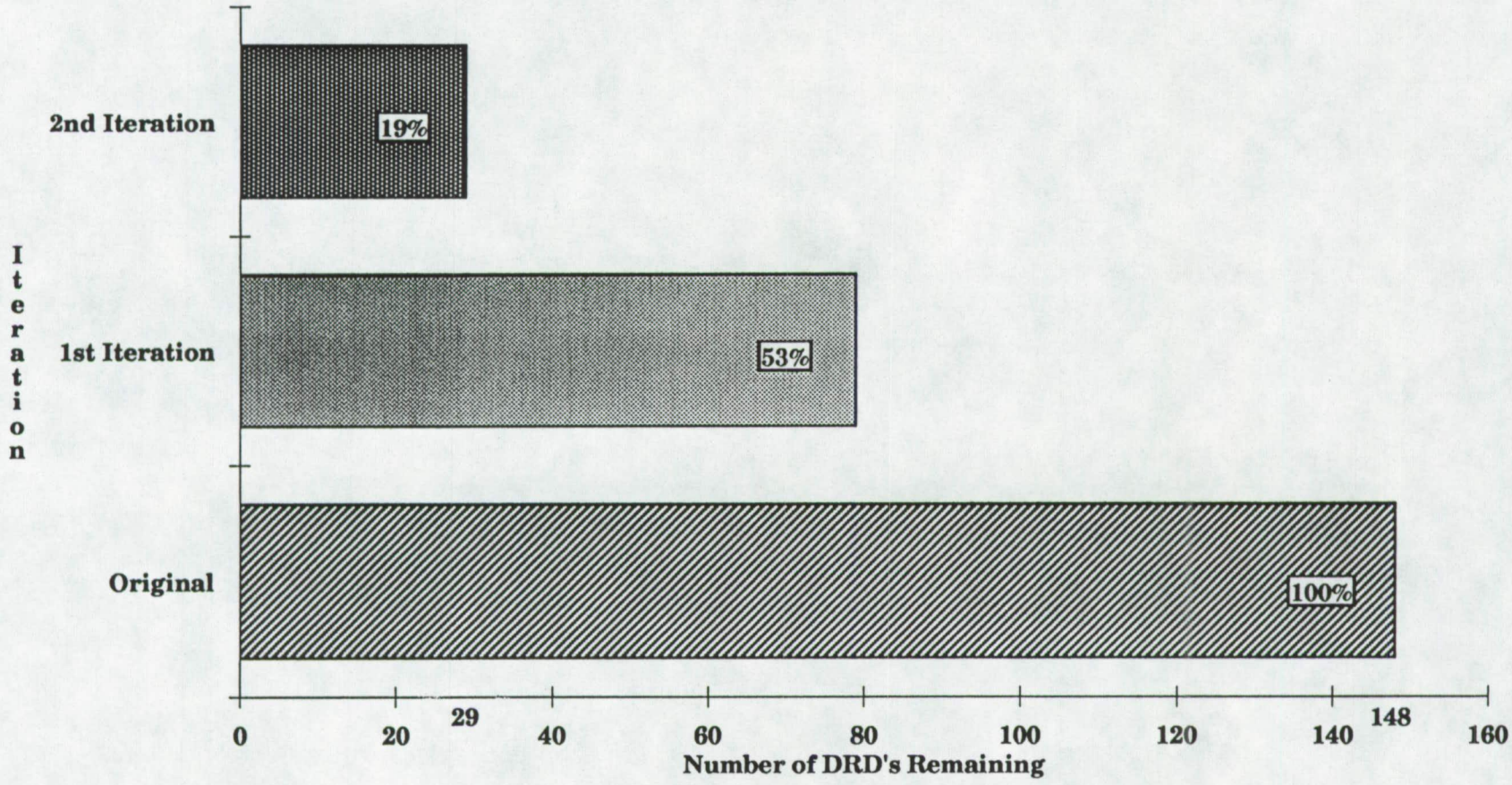
1.18 Cargo Transfer Vehicle

- Refers to the material, effort, and facilities necessary to develop and produce a separate propulsive element (separate from the launch vehicle) which has full rendezvous and docking capability and is used, as required, to place the mission payloads into their final operational environment.
- Includes the structure, propulsion, controls, instrumentation, separation subsystems, and other equipment integral to the elements.
- The interface of this element to the launch vehicle is carried under the Payload Accommodations WBS Element.

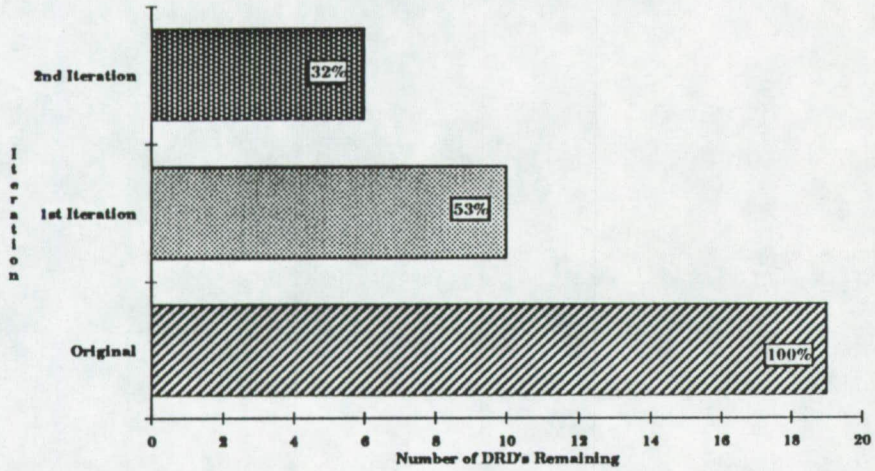
1.2.17 DR Summary

Task report 1.2.17 is a set of bar graphs depicting the results of an effort to reduce the number of data requirements (DRs) for the STME in an effort to reduce cost. The graphs show the original number of DRs, the number of DRs after the effort's first iteration, and the number after the second and final iteration for the total STME acquisition, and for each entity making up the total engine program.

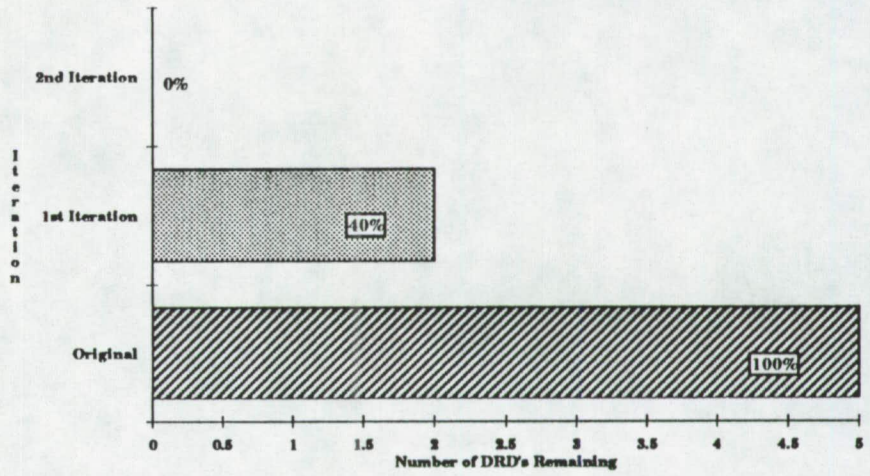
STME DRL Summary



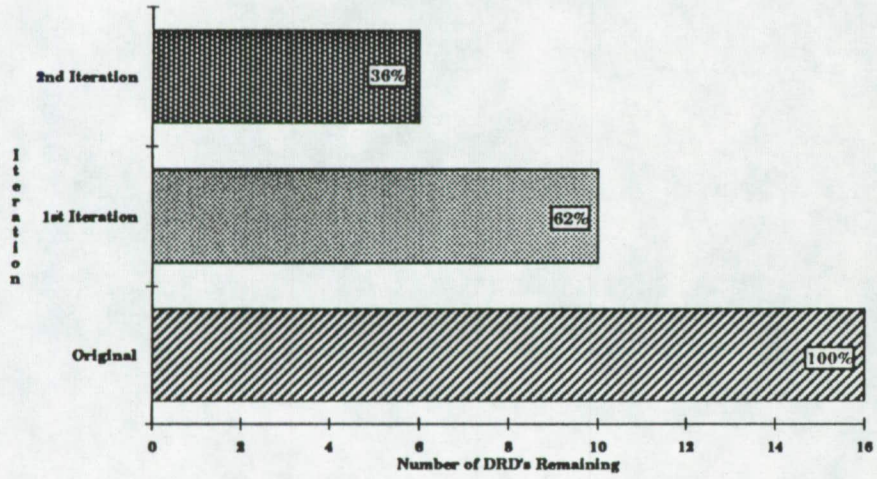
Configuration Management DRL's



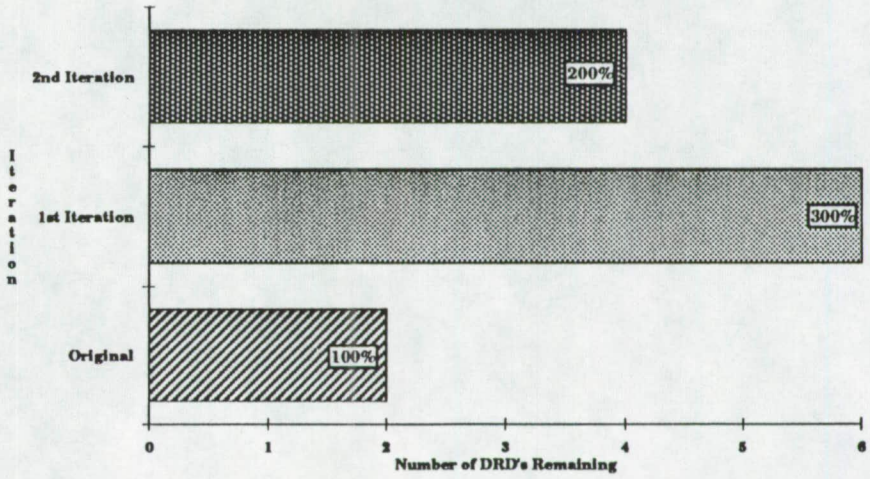
Logistics/Support DRL's

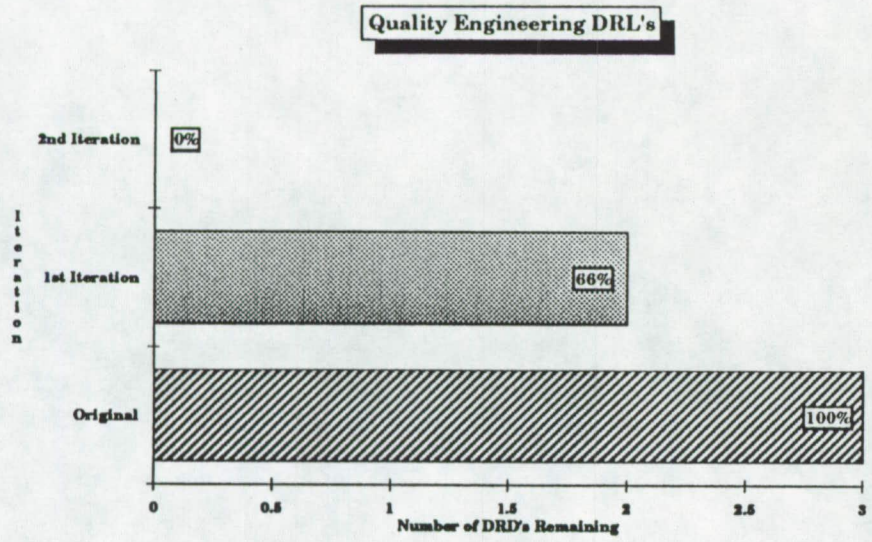


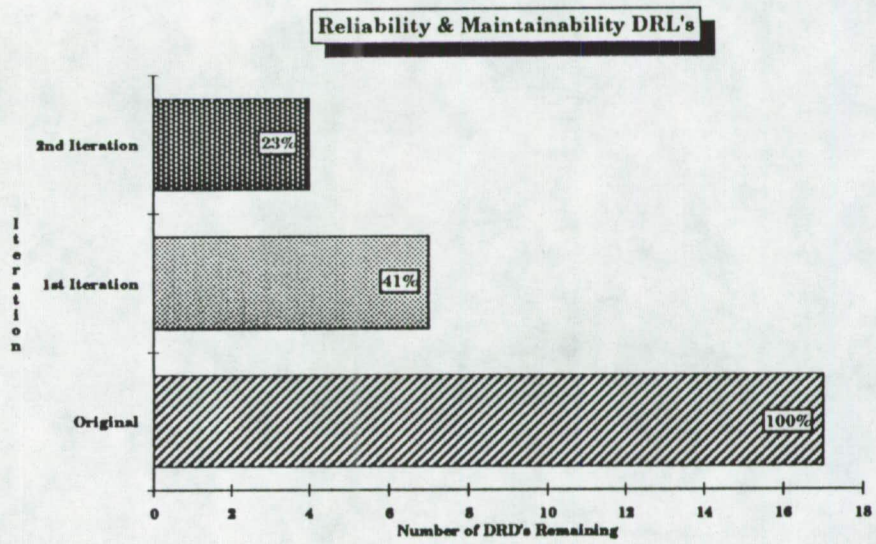
Program Management DRL's

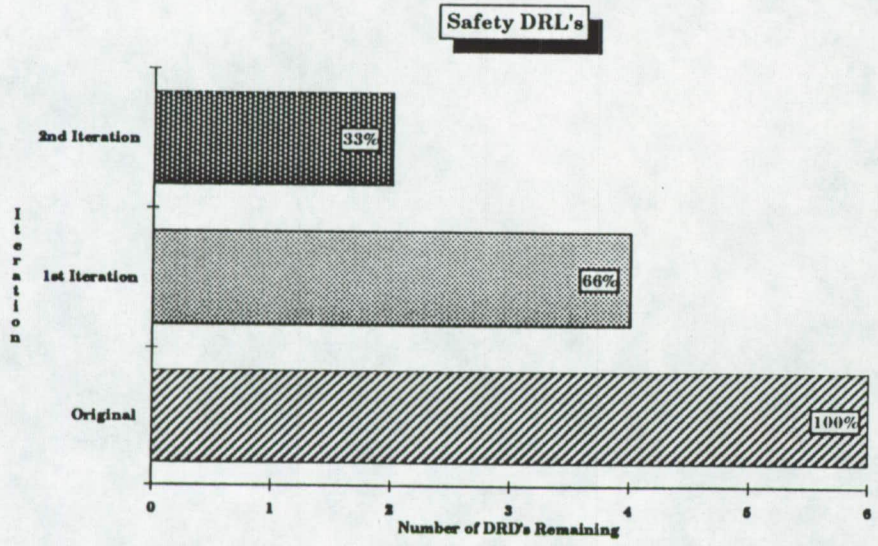


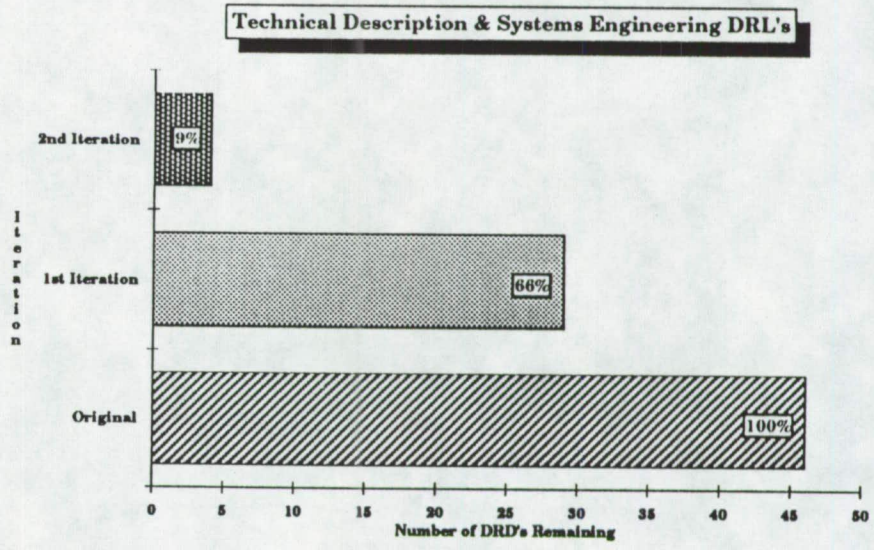
Mission Operations DRL's

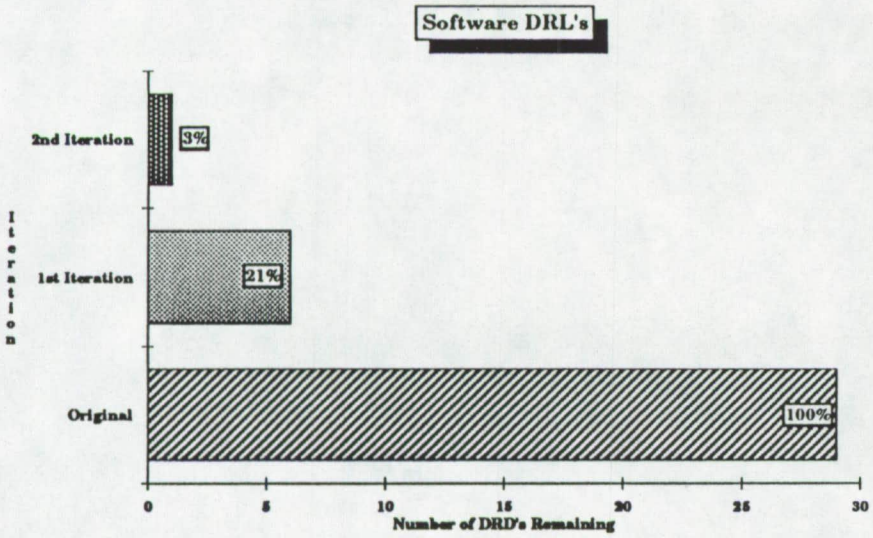


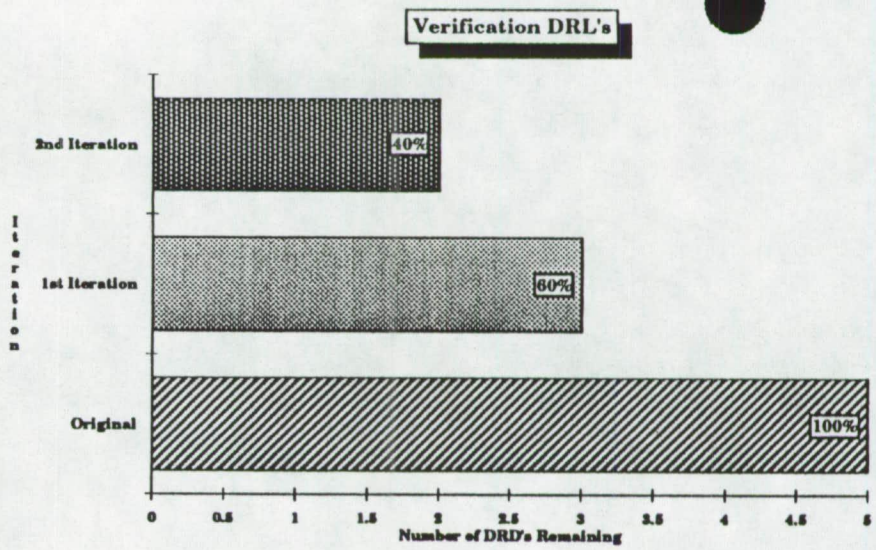

Quality Engineering DRL's
2nd Iteration
0%
1st Iteration
66%
Original
100%
Iteration
0
0.5
1
1.5
2
2.5
3
Number of DRD's Remaining


Reliability & Maintainability DRL's
2nd Iteration
23%
1st Iteration
41%
Original
100%
Iteration
0
2
4
6
8
10
12
14
16
18
Number of DRD's Remaining


Safety DRL's
2nd Iteration
33%
1st Iteration
66%
Original
100%
Iteration
0
1
2
3
4
5
6
Number of DRD's Remaining


Technical Description & Systems Engineering DRL's
2nd Iteration
9%
1st Iteration
66%
Original
100%
Iteration
0
5
10
15
20
25
30
35
40
45
50
Number of DRD's Remaining


Software DRL's
2nd Iteration
3%
1st Iteration
21%
Original
100%
Iteration
0
5
10
15
20
25
30
Number of DRD's Remaining


Verification DRL's
2nd Iteration
40%
1st Iteration
60%
Original
100%
Iteration
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Number of DRD's Remaining

1.3 COST

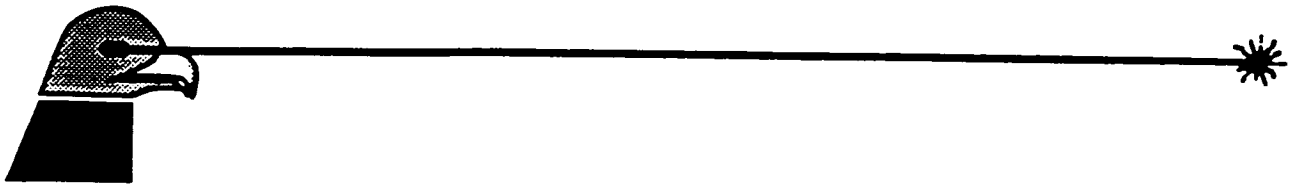
The following is a list of reports associated with USBI's FY92 cost related tasks.

1.3.1 Space Congress Paper - "NLS Cost Containment"

1.3.2 NASA WRAPS

1.3.1 Space Congress Paper - "NLS Cost Containment"

Task report 1.3.1 is the paper titled, "NLS Cost Containment," which was presented at the Twenty-ninth Space Congress on April 22, 1992. This paper discusses cost and schedule growth problems, the primary cost growth cause, NLS cost containment, and the steps necessary to achieve NLS cost containment.



NLS COST CONTAINMENT

by
William S. Rutledge, Director
NASA Program Analysis and Development Division
Applied Research, Inc.
Subcontractor to USBI Co.
Huntsville, Alabama

A paper to be presented at the
TWENTY-NINTH SPACE CONGRESS
Cocoa Beach, Florida
April 22, 1992





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NLS COST CONTAINMENT

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ABSTRACT

Growth in costs and schedules of aerospace projects is all too commonplace. Within NASA, about 70% of cost growth is attributed to underestimation of technical difficulty, 20% to major scope changes and 10% to external impacts. Schedule duration has increased by 50% over the last 15 years. Most growth problems can be traced to incomplete Phase A/B requirements definition, coupled with the resulting incomplete cost estimates.

NLS must be a cost effective, low cost transportation system to be viable. To achieve this goal a cost containment system is required which forces cost, technical and schedule to function together interlocked in a controlled management system.

INTRODUCTION

Cost growth in aerospace programs seems to be the norm these days. Hardly a week goes by without some news article detailing a horror story on a space project involving large cost growth and schedule slips, often coupled with poor technical performance and perhaps even a hint of an attempted cover-up of the matter. These stories imply NASA, DOD and aerospace contractors can not or will not manage their resources effectively.

A recent study by the Federation of American Scientists indicates *the average space project cost 2 1/2 times as much as promised and was 58% behind schedule.* My data base generally supports these factors, however, much depends on what is considered to be the initial estimate. Some programs are tracked against the initial contract value, others from the congressional commitment made at the time the program is approved, and others to early Phase A and Phase B estimates.

Anyway, many of these accusations of large cost growths are all too true. Aerospace "new start" program managers seem to eternally believe they can do the impossible in providing high tech products in record time at garage sale prices. Nevermind that similar programs took twice as long and cost twice as much. This time "we are going to do it differently", "we will freeze the design early and allow no changes", "we will cut out the fat", etc. So they say, but somehow in the real program execution it never seems to work out that way.

Once the program begins, the overzealous claims are quickly overtaken by the grim realities of program turbulence, technical complexities, interfaces, personnel turnover, changing budget priorities and emerging requirements. The inevitable growth in problems, weights, requirements, manpower, costs and schedules, coupled with reduction in margins, performance and planned capabilities has lead to many cost reduction ideas and techniques.

None of these "cure alls" really attack the root cause of cost growth as we will discuss later. Nevertheless, many techniques have come to the forefront as cost reduction tools. In fact, it seems as though a new one is invented everyday. Some of these concepts currently in usage are displayed in Figure 1.

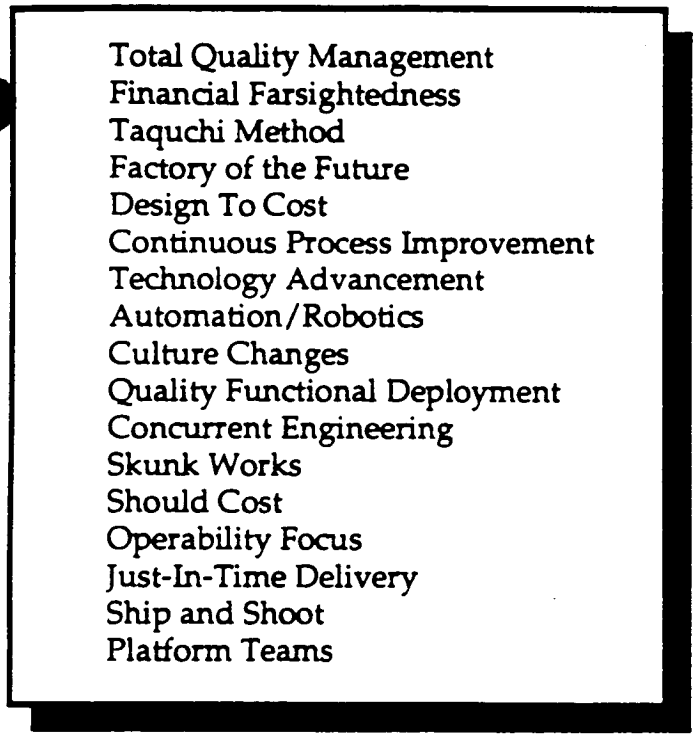


Figure 1. Samples of Current Cost Reduction Concepts

While each of these has cost saving potential, they must be pursued vigorously and continually if any actual savings are to materialize. They must be undertaken with management conviction which lasts throughout the program. *None of these are easy, some have significant up-front costs, most require personnel training and all require constant monitoring and evaluation.* They represent a management commitment to invest in the present for greater rewards in the future.

One recent success story was the Upper Atmosphere Research Satellite (UARS) which was launched this past September and stayed within its $630M budget. Program officials offered the following reasons for good programmatic performance:

1. Use of off-the-shelf hardware
2. Initially planned 4 satellite program reduced early on to a single satellite launch
3. Spacecraft design based on a design that had been used before
4. Interfaces between spacecraft and instruments known early and remained constant
5. Proposed improvements over the basic design and capabilities were not accepted.

These reasons could be called TQM or the like, but it seems more like common sense and technological conservatism that did the trick and, of course, maybe luck.

Other space programs, such as Space Station, Earth Observing System (EOS), New Launch System (NLS) and Space Exploration Initiative (SEI), which initially promised all things to all people appear doomed to major down scoping, delayed starts and price tags larger than the Congress will support. The Space Station's initial technical content and advertised $8 billion cost were totally incompatible from the start. This has kept the program in internal conflict as it has tried to do too much with too little. The downsizing and program rescoping has cost millions and years which could have been more prudently applied to a Space Station whose cost and design were congruent.

COST GROWTH

Space projects have never been without cost growth, but this growth has increased over the years in number and percent. Figure 2 indicates the average percent cost growth for 20 NASA projects launched in the 1970's and for 18 post-1980 projects. The judged cost increases associated with the Challenger accident have been removed from the applicable projects to normalize the data. *Major reasons for the cost growth are (1) underestimate of the program difficulty (complexities, design requirements, interfaces, schedule) 70%, (2) major scope changes 20%, and (3) external impacts (constrained budget, Congress) 10%.*

Part of this increase in cost growth is due to a slow culture change in NASA. NASA now has much less in-house technical capability and has become older, more conservative and is less willing to accept risk or failure. It has lost the boundless

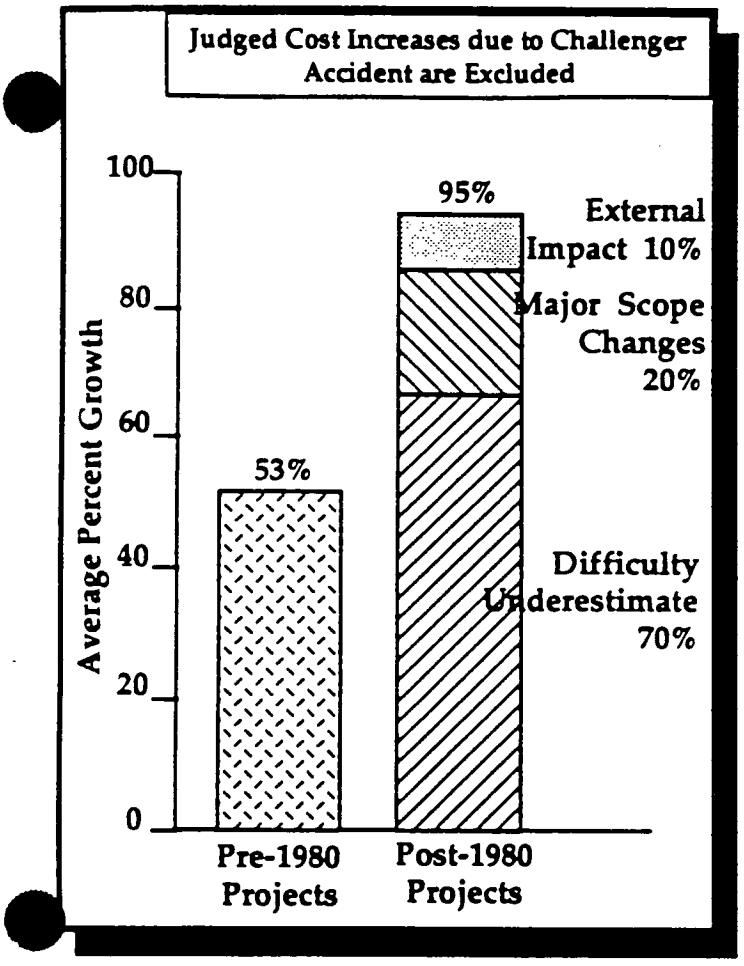


Figure 2. Past and Current Cost Growth Trends in NASA

enthusiasm and air of excitement that was exhibited by its personnel in the 1960s. NASA projects are now more encumbered with bureaucratic processes, documentation, and reporting systems which add cost and manpower. Technology advancements have offset these cost increases to a degree, but not enough to turn the trend around. For example, in today's dollars, the development cost of Space Shuttle's SSME engine was about 30% greater than either of Saturn V's F-1 or J-2 engines. The explanation was that the SSME was considerably more technically demanding. Now, however, the new STME which purports to be a return to a simpler, less technically demanding, low cost system is expected to have the same development cost as the SSME.

The seemly inevitable aerospace cost growth clearly makes the case for adequate program cost contingencies or reserves. I recently added on a major addition to my house. At the outset, I made a detailed cost estimate using the best, most reliable data possible. After all, people have been adding on to their houses for thousands of years so the task appeared simple. A line by line estimate was compiled using vendor quotes, inputs from knowledgeable tradespeople, rules of thumb and actual hardware prices. To this I initially added a 30% cost contingency, but as my planning list grew the dollar total exceeded my budget so I was forced to cut back contingencies to 10%. After the work was complete I compared my estimate to the actual costs line by line. As it turned out I was extremely close (2-3%) on every item which I had estimated. The problem was that there were a large number of items required which I, at the outset, had no idea I needed and had made no estimate for. These more than consumed my meager contingency and made for an overrun. Fortunately it did not make the newspaper headlines.

The point is there is no way to totally quantify the unknown. No matter how much you spend in planning there will still be unexpected discoveries in the execution phase. (Incidentally, a later Figure will address this point.) *The bottom line is that a reasonable cost contingency (20-30%) in a space program is a must.* It is a place holder for the unknown. It is not an optional item "which will get spent up if you include it" — it will get spent regardless! But at dire consequences to the program if it was not included.

SCHEDULE GROWTH

Aerospace projects also now take considerably longer to develop which account for part of the increased cost. Figure 3 indicates the enormous growth in development time for NASA spacecrafts. The schedule slips associated with the Challenger accident have been removed from this data. *Nevertheless, average development time has increased by 50% in the past fifteen years.* The UARS, mentioned earlier, actually was proposed

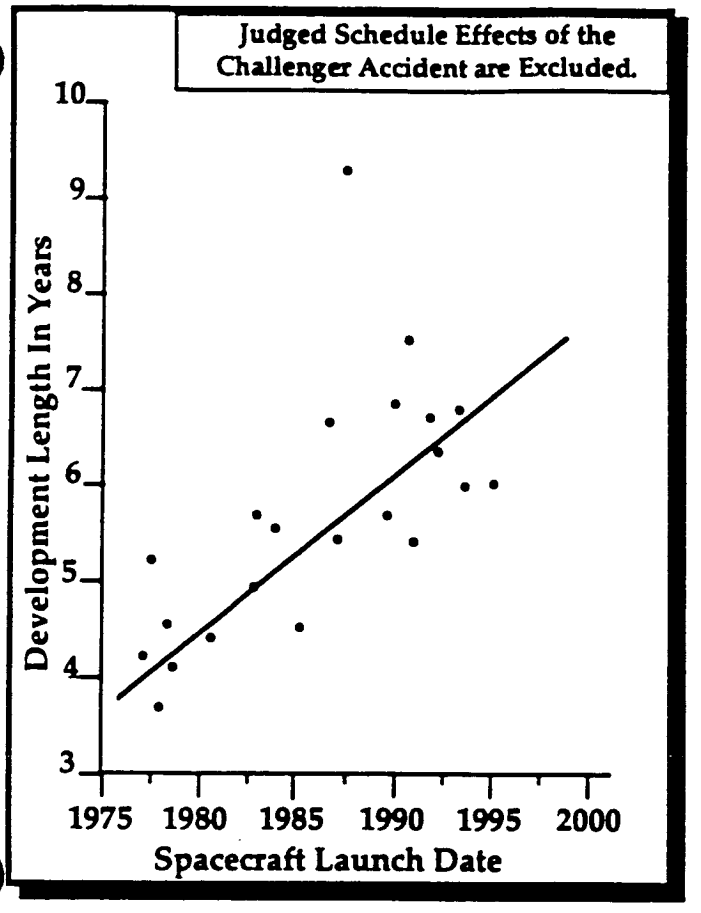


Figure 3. NASA Development Time Trends

in 1978 and took 13 years to gain approval, be built and launched — four years longer than it took to go to the moon.

Another example of schedule slips and cost growth is the Skylab Program Payloads chart shown in Figure 4. This actual data is more unreal looking than any hypothetical illustration I could have created. The actual cost expenditure is plotted along with some 15 NASA Program Operating Plan (POP) requirements over time. There are several trends here that are typical of most space projects. First, in the early years it is usually not possible to spend all the money allocated because of the delays in getting organized and hiring and training personnel. Second, in the later part of a program it is easy to over spend because of the difficulty of getting people off the program. Lastly, the slow ramp-up causes schedule stretch out and cost growth.

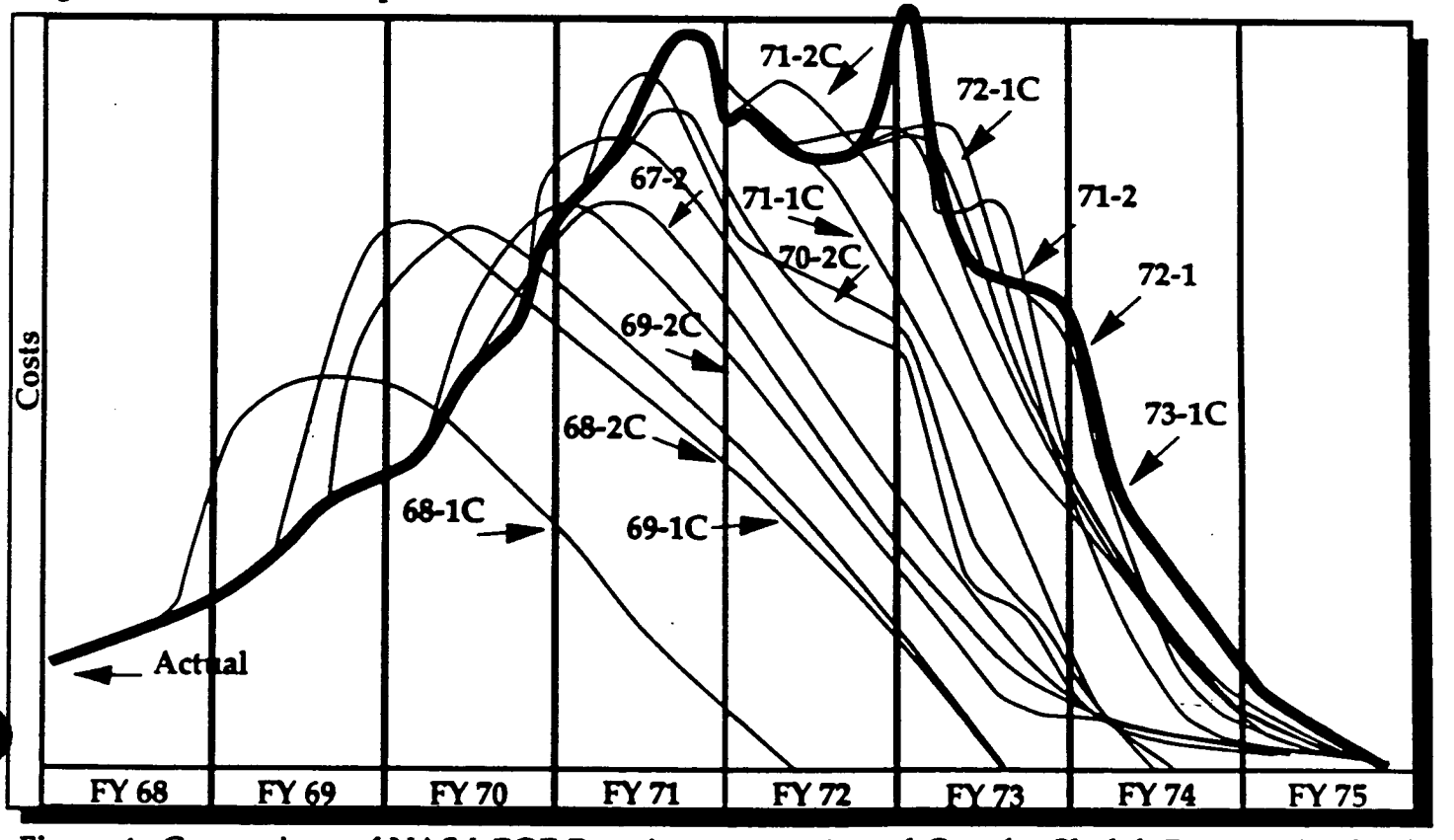


Figure 4. Comparison of NASA POP Requirements to Actual Cost for Skylab Program Payloads

PRIMARY COST GROWTH CAUSE

The causes of cost growth — internal and external, technical and management, foreseeable and totally unforeseeable — are innumerable. *But the primary root cause, I believe, is incomplete technical definition early on.* This leads to requirements understatement; incomplete and inaccurate cost and schedule estimating, and program redirection, growth and downsizing as previously unknown requirements surface. Figure 5 indicates that funds spent in the definition phase can have tremendous payoff in total program cost savings. This plot, with some 25 NASA data points, indicates that if 8-10% of the total program cost is invested in Phase A/B definition, total program growth is held to around 30% above the final Phase B estimate. Spending more dollars and effort on definition seems to offer little payoff, but spending less definitely has a very significant impact on the program total cost.

A number of very important actions should occur during the critical definition period to set the stage for cost containment. These are:

1. Actual user needs are solicited and accomodated.
2. Bona fide requirements established.
3. A workable, conservative preliminary design developed with margins.
4. A streamlined, astute management structure formulated.
5. A total program plan developed.
6. A realistic and inclusive cost baseline estimate made.

If these are done well, the battle for cost containment is half won.

The other half of the battle is to (1) resolutely maintain this baseline and not to let the better become the enemy of the good; (2) establish and utilize powerful management systems which provide program status, tracking, control and sound basis for timely corrective actions as required; and (3) instill within the total government and contractor workforce a desire, a will, a motivation to do things right the first time — on time

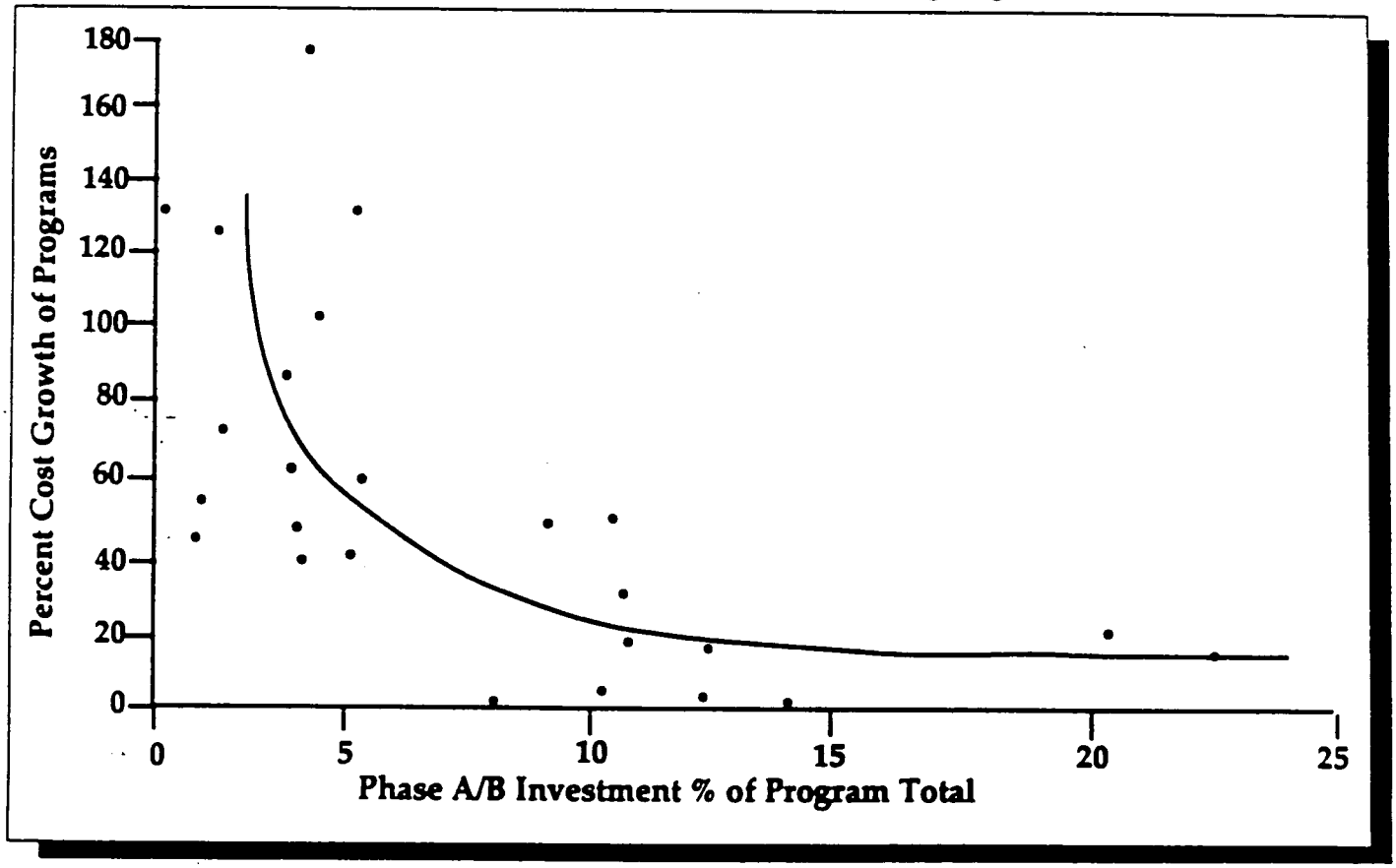


Figure 5. NASA Phase A/B Definition Investment versus Program Total Cost Growth from the Final Phase B Cost Estimate.

with minimum expenditure of resources. Some programs have this technical and management pride, this drive for excellence — many do not.

NLS COST CONTAINMENT

Enough background and preaching on causes of cost growth. What can be realistically done in the NLS program to contain cost and avoid the turmoil associated with other programs? Already there are forces at work which cause the NLS new start grief. These include the massive federal budget deficit, the severe domestic economic recession, the major perturbations of other programs within NASA and DOD, the election year, the lack of strong NLS "users" or proponents, the uncertain NLS technical baseline and the already advertised $10.7 to $12.2 billion DDT&E cost. NLS is being touted as cost-effective and offering low cost transportation. In fact, this has become a major thrust of the NLS new-start justification and these claims must be addressed in a persuasive and business like manner.

On the one hand, the Space Shuttle is a very expensive system to operate and the Titan IV is technologically antiquated in many ways. Therefore, it would seem logical that a new system could easily beat both of them in cost per flight and cost per pound delivered. Especially if that new vehicle was, in fact, a system with common hardware, facilities, manpower and management for a family of vehicles with different payload capabilities.

On the other hand, if the new vehicle has demanding and costly requirements placed on it such as engine out, two separate launch complexes, engine separation system, advanced avionics, Shuttle compatible payload bay, STS heritage, man-rateable, etc., then suddenly its competitive advantage is greatly diminished. The present STS and Titan IV vehicles — costly or antiquated as they are — don't require major DDT&E money nor are they that inefficient in operations cost by comparison to NLS, especially if projected launch rates are modest. The STS operations cost reduction effort, which is now underway here and at other NASA centers, is intended to reduce STS operations cost 3% per year for 5 years or $1.8 billion overall. These efficiencies will surely be applicable to NLS as well. They also free up money which hopefully can be applied to a NLS new start.

W. Edward Denning, the father of TQM, says *"If you always do what you've always done, you'll always get what you always got."* Clearly we must do something different if we are to make NLS a reality. For NLS to attain congressional and national approval, it must show technical and cost advantages over the present launch systems. I will leave the technical superiority discussion to others and concentrate on the cost justification. NLS must be capable of providing low cost transportation for payloads and yet achieve this aim within a DDT&E budget which will surely be constrained both in total and year-by-year costs. *To fulfill this difficult goal, NASA and the Air Force must put major emphasis on cost containment and adopt a new development culture where (1) the cost impact of every program decision is carefully weighted before implementation, (2) where low operating costs drive every design trade, and (3) where NLS management make design and program architecture converge on costs rather than vice versa.*

I envision a NLS cost containment system which would be an interactive process forcing cost, technical and schedule to function together, interlocked in a controlled and viable management system. While "zero cost growth" is not possible, "cost containment" within acceptable bounds is an achievable management goal. NLS which involves many program elements, centers, contractors and a NASA/Air Force partnership, has unforeseens and unknowns which can not be totally anticipated. Even with descoping of technical requirements, schedule adjustments and cost contingencies, some cost growth is likely. With an integrated cost containment plan fully supported by NLS management, such cost growth can be minimized and contained. This managed containment will permit a viable NLS program to proceed in a very cost effective manner.

STEPS TO NLS COST CONTAINMENT

The proposed cost containment framework consists of five key steps as shown in Figure 6.

1. **Establish the baseline program.**
2. **Establish cost targets and contingencies.**
3. **Establish cost containment management systems.**
4. **Perform tracking, analyses and evaluation.**
5. **Make timely, informed decisions.**

Figure 6. Five Steps to Cost Containment

The approach for NLS cost containment is an evolutionary process starting with program definition and continuing through design, development and operations. Cost containment can best be achieved through a systematic approach for establishing meaningful and achievable technical, schedule, and cost baselines and the effective integration and implementation of this program.

The NLS cost containment system is obviously considerably more involved than can be detailed in this short paper. Many on-line, existing mangement systems would be utilized, although in a more coupled and dynamic manner; several new systems would be introduced; more emphasis would be placed on cost and schedule estimating; techniques such as risk assessments, trend and variance analyses, action tracking and independent evaluations would be used to a greater degree; and fall-back and alternate solutions would be developed ahead of any need. In summary fashion, the five steps to achieve the NLS cost containment goal are explained below.

(1) *Establish the baseline program*

The crucial program definition work cited earlier must be done for NLS. Requirements definition and preliminary design work must establish a baseline which (1) supports user needs and (2) is operability focused. Critics of NLS would say that neither of these keystones are presently in place. Now is the time to focus on these two areas in sufficient detail to allow the program to move through what has almost become a "go-no go" gate. This baseline provides the basis for detailed and realistic schedule and cost estimates. Obviously this is an iterative task with many trades performed to insure that NLS requirements are cost optimized. Appropriate design margins must be included and the operations and user impacts of requirements and preliminary design work must be given the highest priority. Cost analysts and designers must work closely together in a proactive environment. Mission success should continue to be the primary emphasis, but with a proper balance of schedule and cost considerations. Contingency plans should be developed at the outset for each program element that would allow for fall-back positions in the event technical problems or budgetary ceilings are encountered that impact established technical, schedule or cost baselines.

(2) *Establish cost targets and contingencies*

A tailored design-to-cost approach should be implemented where specific cost goals are assigned, ownership assumed, designs traded and cost maintained within these target values while still meeting technical requirements. Adequate cost reserves should be established and used very judicially. For the most part, cost increases in one area must be offset by reductions in other areas. A concerted effort should be made to instill in all NLS participants the idea that the challenge of cost containment can be met. Appropriate rewards and incentives would have to be incorporated at all levels to motivate participants. Education and training programs would be required to influence, or perhaps even change, individual mind-sets in order to achieve the desired results.

(3) *Establish cost containment management systems, controls and reporting requirements*

Program management processes, tools and techniques that are currently being used would have

to be augmented with new and innovative ideas. In this enlightened age it is now possible to develop interactive cost, technical and schedule reporting, planning, tracking and control management systems complete with projected alternatives and options and their associated risks and costs. Problems could thus be identified and fixed early before they create "show stoppers". Likewise, resources could be allocated to the choke points and technical and management talent directed to the high priority tasks.

(4) *Perform tracking, analyses, assessment and evaluations.*
Cost containment cannot be accomplished from tracking and statusing alone. Nor can it be accomplished if cost, technical and schedule are dealt with as individual entities. This step provides the data and recommendations used for NLS program decisions and problem resolutions.

The program control tools, procedures and processes, cost estimating models, and the program status and tracking system would be used to manage the NLS program, identify potential problems and to develop alternative approaches. The baseline would be in the form of a logic network model, resourced, time phased and risk quantified. Individual nodes with the greatest risk would be analyzed for alternative approaches to eliminate or abate risk. Development of alternative approaches would be a continuous process. Network modeling and simulations would reveal areas of greatest risk to cost and schedule. In addition, trend analyses would reveal unfavorable cost or schedule trends which would be evaluated. Potential problems would also be identified from such sources as program reviews and program documentation or from the program status tracking effort. From these, alternative approaches would be developed and iterated until the most suitable approach is attained within cost containment consideration. Of course, the key to identifying alternative approaches lies not in the automated system or model but in the "human element"; the ability of the engineer/analyst to identify those areas where risk may be excessive and to formulate alternative solutions.

(5) *Make timely, informed decisions.*
Containing cost while maintaining program continuity is a difficult undertaking. However, decision making when supported by timely and accurate data, trades studies, and risk analyses as described above, would become a far less hazardous(and sometimes, haphazardous) endeavor. It still would require experience, common sense, management and technical judgement — and the ability to say "no" to good ideas and proposals if they exceed the program's requirements or costs. Given these attributes, plus immediate access to valid, timely and concise data, NLS technical and management personnel can provide this nation a needed and cost effective new launch system.

BOTTOM LINE

NLS must take full advantage of the "age of information" in which we live and use this information to plan, to execute and, if necessary, to change. NLS must begin with well-grounded requirements which are consistent with user needs and operability considerations optimized to acceptable low cost solutions. NLS must stay the course with cost, technical and schedule interlocked and armed with good data to support every decision.

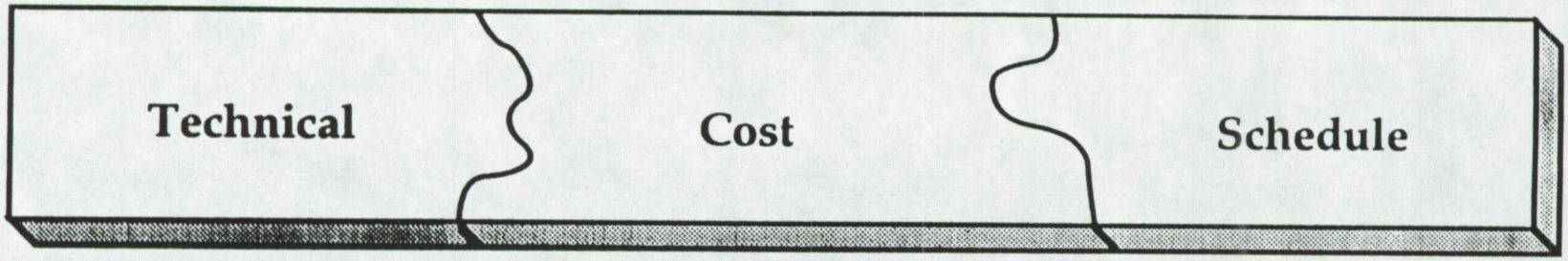
Cost containment has never been easy. Cost containment will never be very easy. *But cost containment within acceptable limits is achievable with good data, good tools, good people and determination.*

The views and opinions expressed by the author in this paper are his own and are based on his 30 years of experience in aerospace cost estimating and analysis. They do not necessarily reflect any official position of ARI, USBI, NASA or the U.S. Air Force.

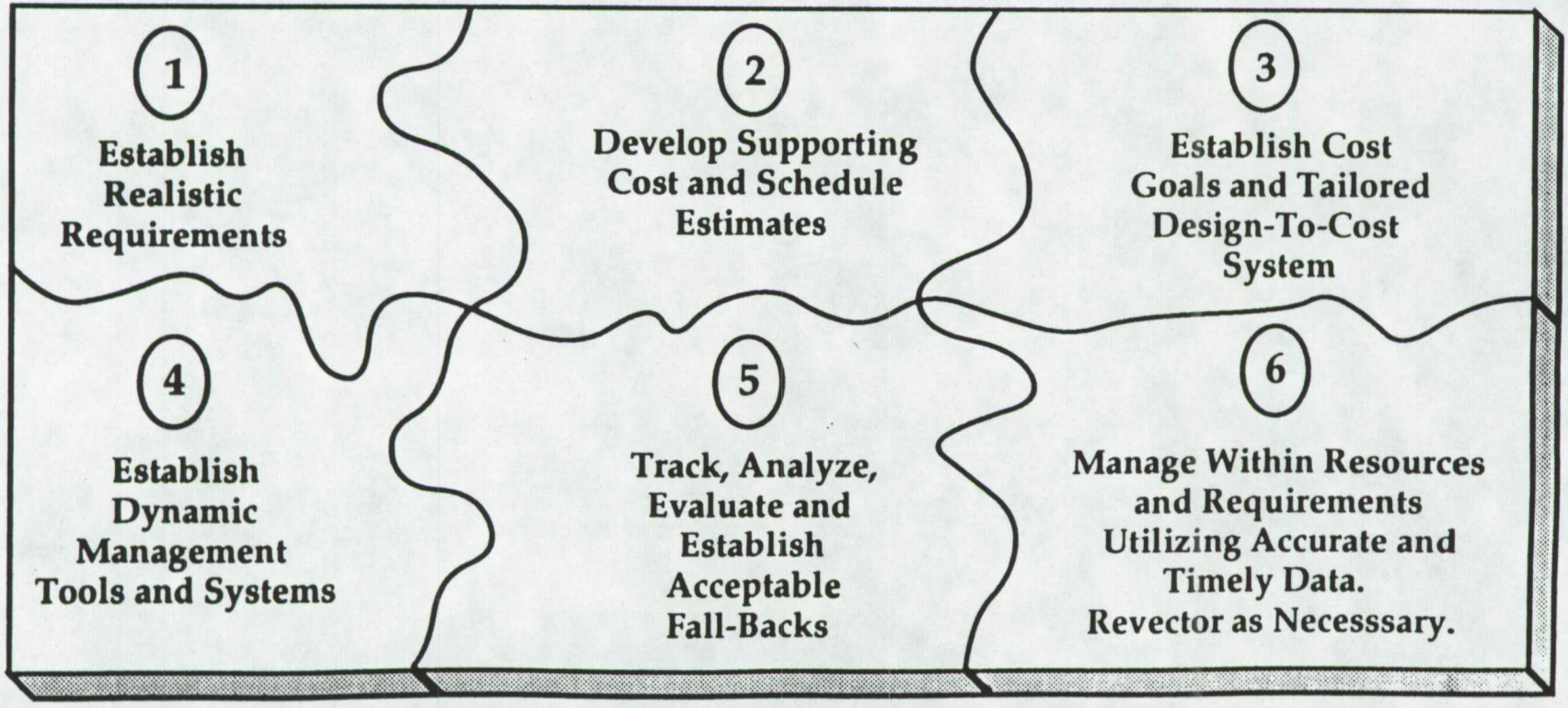
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Applied Research, Inc.

NLS COST CONTAINMENT SYSTEM



An integrated, interlocked process which forces all pieces of the puzzle to function together cost effectively.



William S. Rutledge
Biography

Mr. Rutledge is Director, NASA Program Analysis and Development Division of Applied Research, Inc. (ARI). For the past five years at ARI he has headed a number of NASA-related cost analysis and estimating contracts including one for USBI Co. to provide programmatic support for NLS, and formally to Shuttle-C. Prior to ARI, Mr. Rutledge was Chief of MSFC's Engineering Cost Group for 21 years. He established the office; developed cost models and methodologies, approaches and techniques; and instituted, expanded and maintained the NASA-wide cost data base. He directed, validated and performed parametric cost estimating for many new NASA projects including High Energy Atmospheric Observatory (HEAO), Space Shuttle, Space Station, Hubble Space Telescope (HST), Orbital Maneuvering Vehicle (OMV), and lead cost activities for countless definitions studies of other spacecrafts, launch vehicles, upper stages, experiments and payloads. He was involved in cost trades, sensitivities, economic analyses and cost risk studies associated with these NASA systems to optimize designs, cost effectiveness and schedules. He was MSFC's senior cost consultant for all cost estimating matters and served on NASA-wide cost teams for Space Station and Space Shuttle.

Mr. Rutledge holds degrees in engineering and business. He is a Certified Cost Estimator/Analyst, a member of the Society of Cost Estimating and Analysis, and the International Society of Parametric Analysts. He is a former member of the American Institute of Aeronautics and Astronautics' Technical Committee for Economics.

1.3.2 NASA WRAP

Task report 1.3.2 is a chart describing the NASA DDT&E, flight unit, fee, program support, and contingency WRAP percentages.

NASA WRAP - PERCENTS

DDT & E WRAPS
PERCENT WBS ITEM OF TOTAL

	UNMAN PROTYPE	UNMAN PROFLIGHT	LAUNCH VEHICLE	MANNED	AVERAGE FACTOR
SUBSYSTEM SUBTOTAL + TEST HDWR	59%	60%	56%	59%	60%
INTEG., ASSY., CHECK-OUT	3%	5%	2%	5%	3%
SYSTEM TEST OPNS	6%	6%	5%	9%	6%
GSE	13%	12%	19%	9%	13%
SE&I	12%	11%	12%	12%	12%
PROGRAM MANAGEMENT	7%	6%	6%	6%	6%
SYSTEM LEVEL SUBTOTAL	41%	40%	44%	41%	40%
TOTAL	100%	100%	100%	100%	100%

FLIGHT UNIT WRAPS
PERCENT WBS ITEM OF TOTAL

SUBSYSTEM SUBTOTAL	67%	70%	72%	74%	70%
INTEG., ASSY., CHECK-OUT	9%	9%	13%	9%	10%
SYSTEM TEST OPNS					
GSE					
SE&I	14%	11%	9%	7%	11%
PROGRAM MANAGEMENT	10%	10%	6%	10%	9%
SYSTEM LEVEL SUBTOTAL	33%	30%	28%	26%	30%
TOTAL	100%	100%	100%	100%	100%

ADDITIONAL WRAPS:

FEE	10%	
PROGRAM SUPPORT	15%	
CONTINGENCY	15%	(TO 30%)
GRAND TOTAL	145.5%	

IN ADDITION, A 5-15% LEVEL I/II WRAP AND HEADQUARTERS APA OF 5-10% ARE SOMETIMES ADDED.

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2.0 ***TECHNICAL/SYSTEMS ENGINEERING***

2.1 Omitted

2.2 NLS Engine-Out Analysis

2.3 NLS Avionics Analysis

2.4 NLS 2-Stage versus 1.5-Stage Comparison

2.5 HLLV/ASRB Compatibility

2.6 Architecture Definition Process

2.7 50K Vehicle Justification

2.8 SE&I Organization and Responsibilities

2.9 NLS Systems Engineering and Integration

2.10 Level II SRD Comments and Identification of Cost Drivers

2.11 Vehicle-Engine ICD Comments

2.12 Comparison of SRD v6.0 with MSFC Requirement-1978

2.1 Omitted

2.2 NLS Engine-Out Analysis

Task report 2.2 documents the results of a study whose objectives were to (1) define the engine-out coverage afforded by retargeting to a lower altitude abort orbit at engine loss and (2) quantify implementation cost for abort orbit methodology. From the "quick-look" assessment made, it was concluded that abort to secondary orbit is not a major driver/option and has little to no impact on the overall engine-out trade study.

NLS Engine Out Analysis

Impact Assessment of Utilizing an Abort Orbit



March 6, 1992

Background

- Systems Engineering was requested to plan a study
 - Define the engine out coverage afforded by retargeting to a lower altitude abort orbit at engine loss
 - Quantify implementation cost for abort orbit methodology
- Plan was developed
 - 3 week study
 - 130 man hours
 - 70 CPU Hours (VAX)
- "Quicklook" assessment was made

 Result: Abort to secondary orbit is not a major driver/option and has little to no impact on overall Engine Out trade study
- Cursory report was requested on results of "Quicklook"

NLS Engine Out Analysis

UNITED TECHNOLOGIES USBI

Impact Assessment of Utilizing an Abort Orbit

March 6, 1992

Quicklook Assessment

Orbital Lifetime

- Nominal Stage 1.5 Mission Profile
 - 80 x 150 nmi insertion orbit at perigee
 - ~1.4 days lifetime*
- Abort Orbit
 - Less Energy than 80 x 150 orbit
 - < 1.4 days lifetime*
 - Example: 80 x 80 nmi orbit ⇒ 6 hrs lifetime*

Payload Performance

- Small ΔV savings for retargeting
 - ΔV = -126 fps for retargeting to 80 x 80 nmi
 - 0.5% reduction in total velocity requirements
 - Minimal impact on payload performance
 - Minimal impact on Engine Out coverage (~ 5 secs)

* for payloads with 1.0 ft^2/slug ballistic coefficient

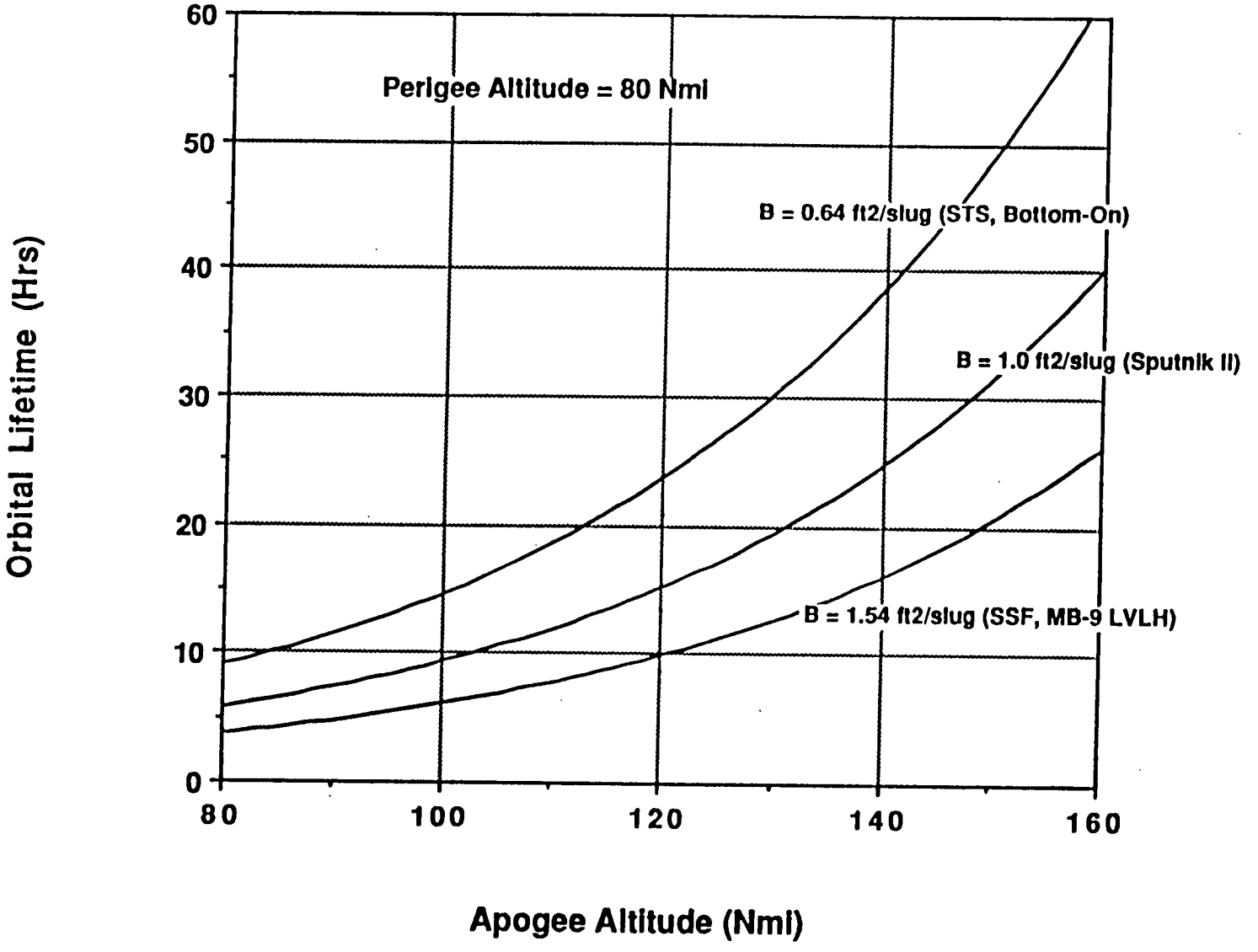
NLS Engine Out Analysis

UNITED TECHNOLOGIES USBI

Impact Assessment of Utilizing an Abort Orbit

March 6, 1992

Orbital Lifetime vs. Apogee Altitude



Avionics System

Guidance Scheme Requires Modification

- Adaptive Guidance
 - Real-time recalculation of required end conditions based on which engine out and mission time

 Or
 - Multitude of precalculated data tables stored in flight computer memory to accomplish the above

- Either approach is an impact to flight computer memory and process time
 - Adaptive guidance may require addition of new dedicated onboard computer just for guidance calculations

- Addition of sensors to determine vehicle angle of attack may be required

NLS Engine Out Analysis

UNITED TECHNOLOGIES USBI

Impact Assessment of Utilizing an Abort Orbit

March 6, 1992

"Quicklook" Conclusions

- Orbital lifetimes limit the usefulness of an abort orbit
- No appreciable payload gain
- No appreciable gain in additional Engine Out coverage
- Increase in cost and complexity of GN&C

Abort to Secondary Orbit is not a major driver/option and has little to no impact on overall Engine Out trade study

2.3 NLS Avionics Analysis

Task report 2.3 documents the results of study whose objectives were to determine the design drivers for the NLS avionics and define the avionics architectural approach to satisfy program requirements. The conclusions made from the study were that no pad access is the primary driver for the fourth string of avionics. Also, cost/benefit trades which consider (1) pad access to replace failed units and (2) improvements in avionics box level reliability should be undertaken.

PRIMARY DESIGN DRIVERS

- VEHICLE MISSION STATISTICAL RELIABILITY 0.98 (LEVEL II SRD 3.4.2)
 - AVIONICS ALLOCATION 0.993
- VEHICLE PROBABILITY OF LAUNCH WITHIN 10 DAYS 0.90 (SRD 3.4.2)
 - AVIONICS ALLOCATION 0.967
- NO ON PAD ACCESS
- HIGH VALUE CARGO
- MAN RATEABLE
- SSF RENDEZVOUS

SECONDARY DESIGN DRIVERS

- EEE PARTS AVAILABILITY
- COMMONALTY, CTV-CORE
- SIMPLICITY HW&SW
- TECHNOLOGY UPGRADEABLE
- POWER-UP TIME - PRE LAUNCH & MISSION
 - CORE 335 HRS + 3 HRS
 - CTV 335 HRS + 132 HRS
- SINGLE EVENT UPSET (SEV)

AVIONICS ARCHITECTURAL APPROACH TO SATISFY REQUIREMENTS

- SUBJECT OF FOLLOWING AVIONICS PDT TRADES

 3A-004 AVIONICS FAULT TOLERANCE FOR CORE
 3A-005 AVIONICS FAULT TOLERANCE FOR CTV
 3A-006 LAUNCH WITH FAULT
 3A-035 CTV COLLISION AVOIDANCE
 3A-036 FIXED OR SCALABLE FAULT TOLERANCE
 3A-039 FAULT TOLERANT ARCHITECTURE

- STUDY PARTICIPANTS: MSFC, JSC, USBI, BOEING, GD, MARTIN, ROCKWELL, LOCKHEED

- SUMMARY OF TRADE RESULTS

 - FAIL OPERATE i.e. 1 FAULT TOLERANT IS REQUIRED

 -- STATISTICAL ANALYSIS
 -- FIELD FAILURES OF DELTA, CENTAUR, TITAN, IUS, SHUTTLE

 - IMPLEMENT VIA TRIPLE SINGLE STRING VOTED FOR FLIGHT CRITICAL

 – HOWEVER, TO MEET LAUNCH ASSURANCE QUAD VOTED STRING IS REQUIRED FOR FLIGHT CRITICAL

- CYCLE 0 BASELINE

 - QUAD SINGLE STRINGS VOTED FOR FLIGHT CRITICAL

 - DUAL SINGLE STRING FOR NON FLIGHT CRITICAL

ORIGINAL PAGE IS
OF POOR QUALITY

NLS Requires Fault Tolerance

Assured Mission Success

Reliability Assessment

Assumes:
- No Manufacturing Problems
- No Incorrect Maintenance
- No Overstress Of Components
- No Exceeding Environment Reqmts
- No Design Errors
- No Specification Errors

Fault Tolerance

Improves Coverage of:
- Manufacturing Defects
- Human Induced Errors
- Overstress in Testing

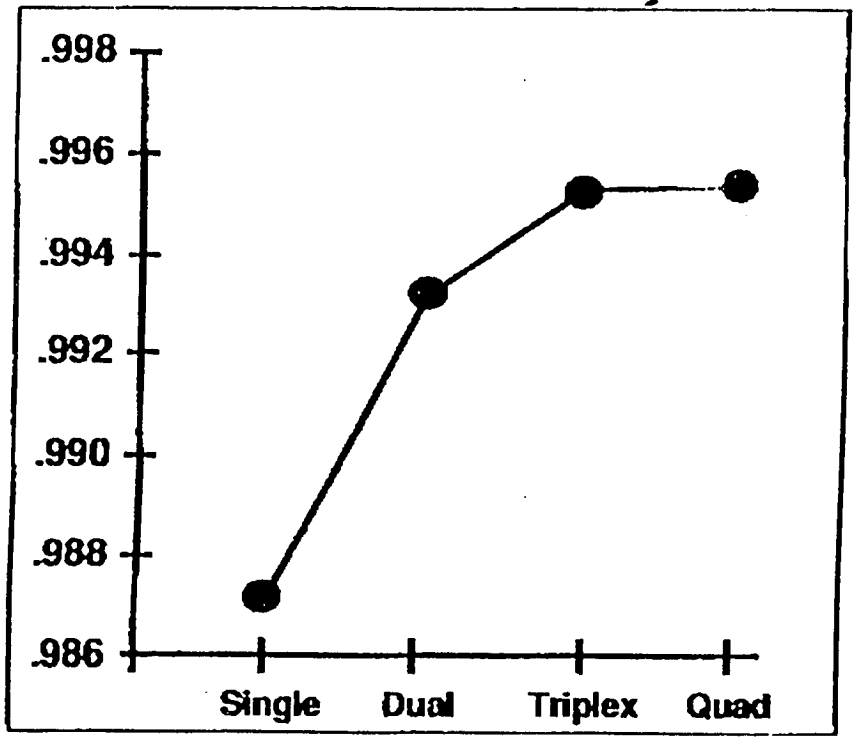
Limited Coverage of:
- Design Errors
- Specification Errors

Reliability Assessment Alone Does Not Protect Against Many Real World Failure Sources

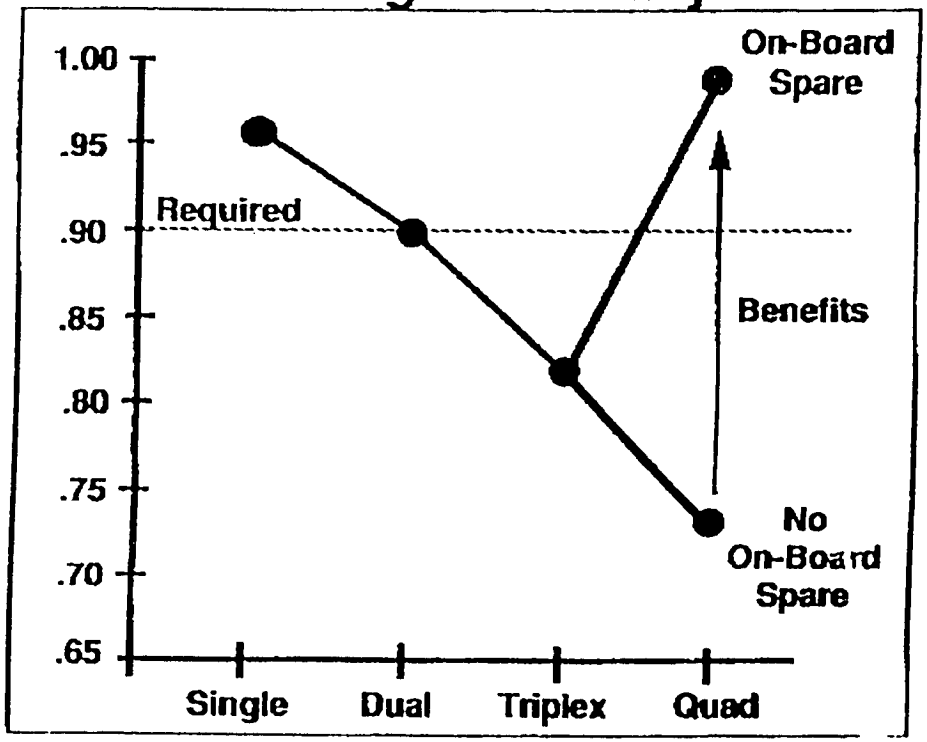
Balancing Reliability and Dependability

Reliability Model Data

Ascent Reliability



Preflight Reliability*



* Mechanical systems not modeled as active during pre-flight phases

Empirical Data*

STS pre-flight failure data:

- **4 preflight failures due to avionics through STS-39 (3 required remove & replace action)**

* RI study on STS launch delays, 7/91

CORE RELIABILITY

ASSUMPTIONS

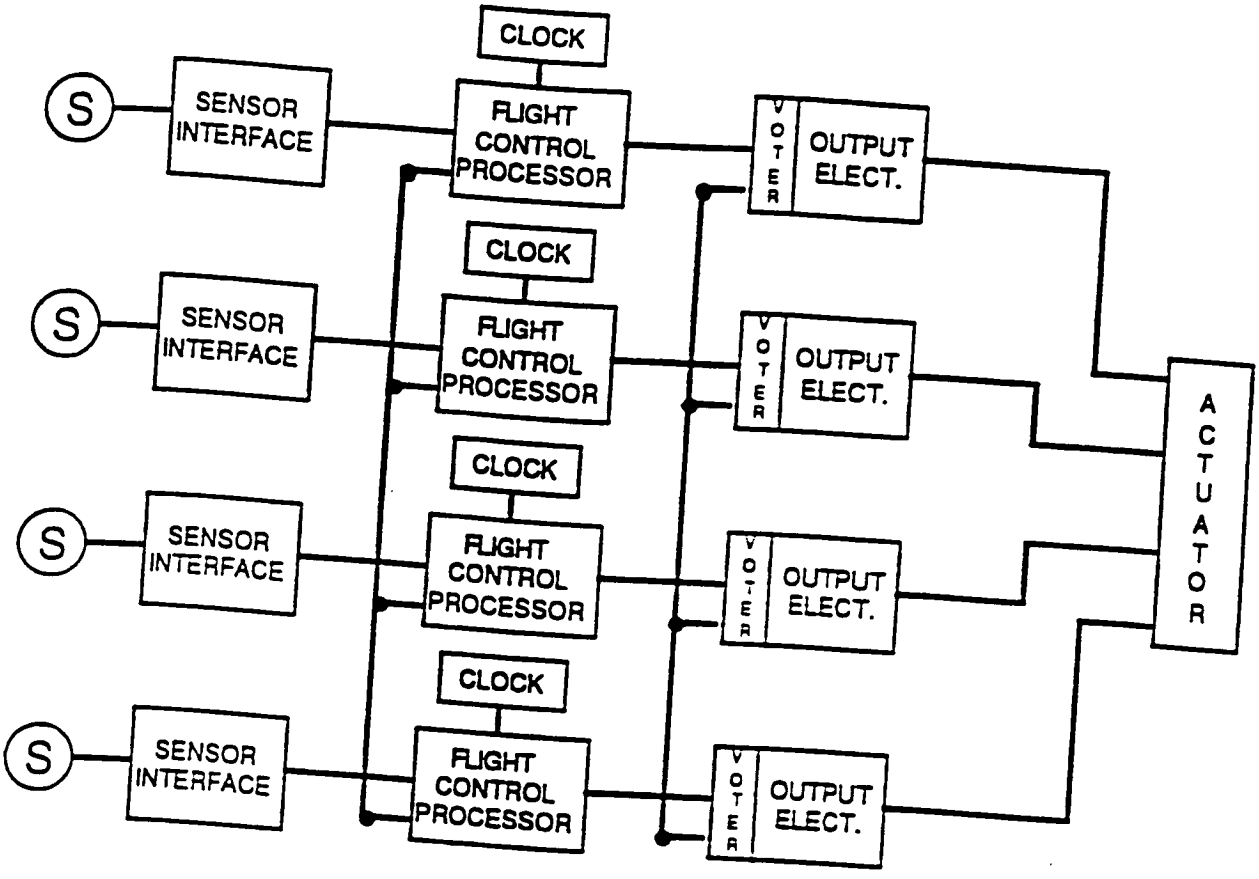
- Mission Length - 3 hours (15 min. of Missile Launch, 2 hrs. and 45 min of Space Flight)
- Prelaunch Duration - 335 hours
- Reliability numbers are based on the calculated reliability of an Atlas Inertial Navigation Unit (INU)
- Analysis based on estimates of 8 and 10 units per channel. Units represent circuitry with equivalent reliability to an INU.
- Redundant avionic channels replicate all units

PRELAUNCH RELIABILITY

PARTS GRADE	QUALITY FACTOR	TRIPLEX - NO FAULTS 8 UNIT/CH	TRIPLEX - NO FAULTS 10 UNIT/CH	QUAD - 1 FAULT 8 UNIT/CH	QUAD - 1 FAULT 10 UNIT/CH
1	1.0	0.91338409	0.89292874	0.99489854	0.99216670
2+	0.8	0.90309758	0.88037631	0.99359940	0.99019301
2	0.7	0.89799778	0.87416633	0.99289940	0.98913214
2	0.25	0.88287020	0.85579762	0.99060327	0.98566394

MISSION RELIABILITY

PARTS GRADE	QUALITY FACTOR	TRIPLEX 8 UNIT/CH	TRIPLEX 10 UNIT/CH	QUADRAPLEX 8 UNIT/CH	QUADRAPLEX 10 UNIT/CH
1	1.0	0.99999806	0.99999697	0.999999998	0.999999996
2+	0.8	0.99999754	0.99999616	0.999999997	0.999999994
2	0.7	0.99999726	0.99999573	0.999999997	0.999999993
2	0.25	0.99999633	0.99999427	0.999999995	0.999999989



In this configuration two of three channels are voted with the fourth left as a hot backup.

In the event of a fault in one of the voted elements it is dropped out and the fourth brought in to replace it.

There is little or no cross-strapping between elements but the voter requires a high degree of intelligence.

Assumes no simultaneous failures within a system, simultaneous being defined as occurring within the same major cycle.

Mission critical avionics must be a minimum of fail-operational/fail-notify after launch commit.

Provides capability to sustain a fault prior to launch commit and still have minimum fault tolerance needed for flight.

Figure 3.5-7 Avionics Quadraplex Architecture

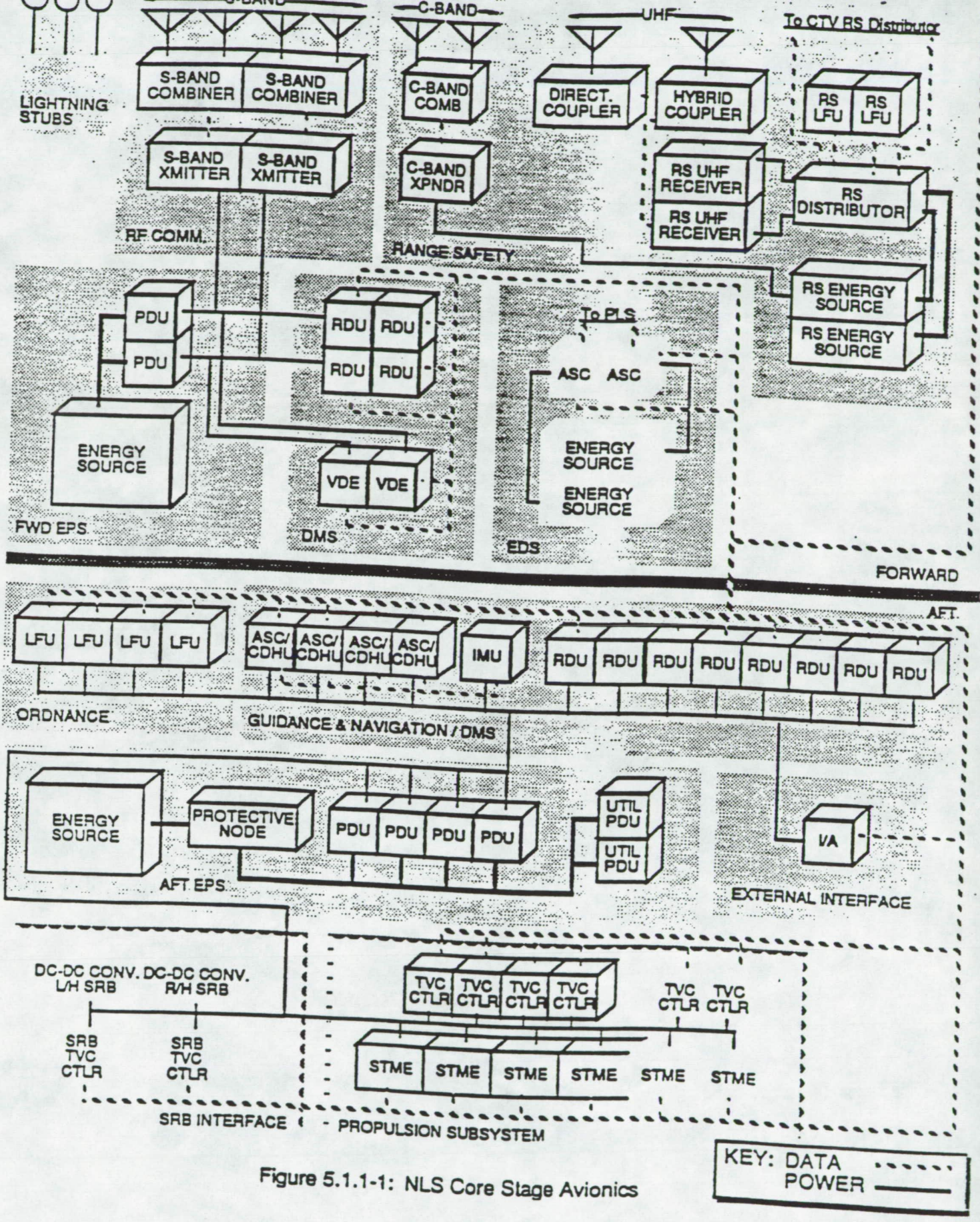


Figure 5.1.1-1: NLS Core Stage Avionics

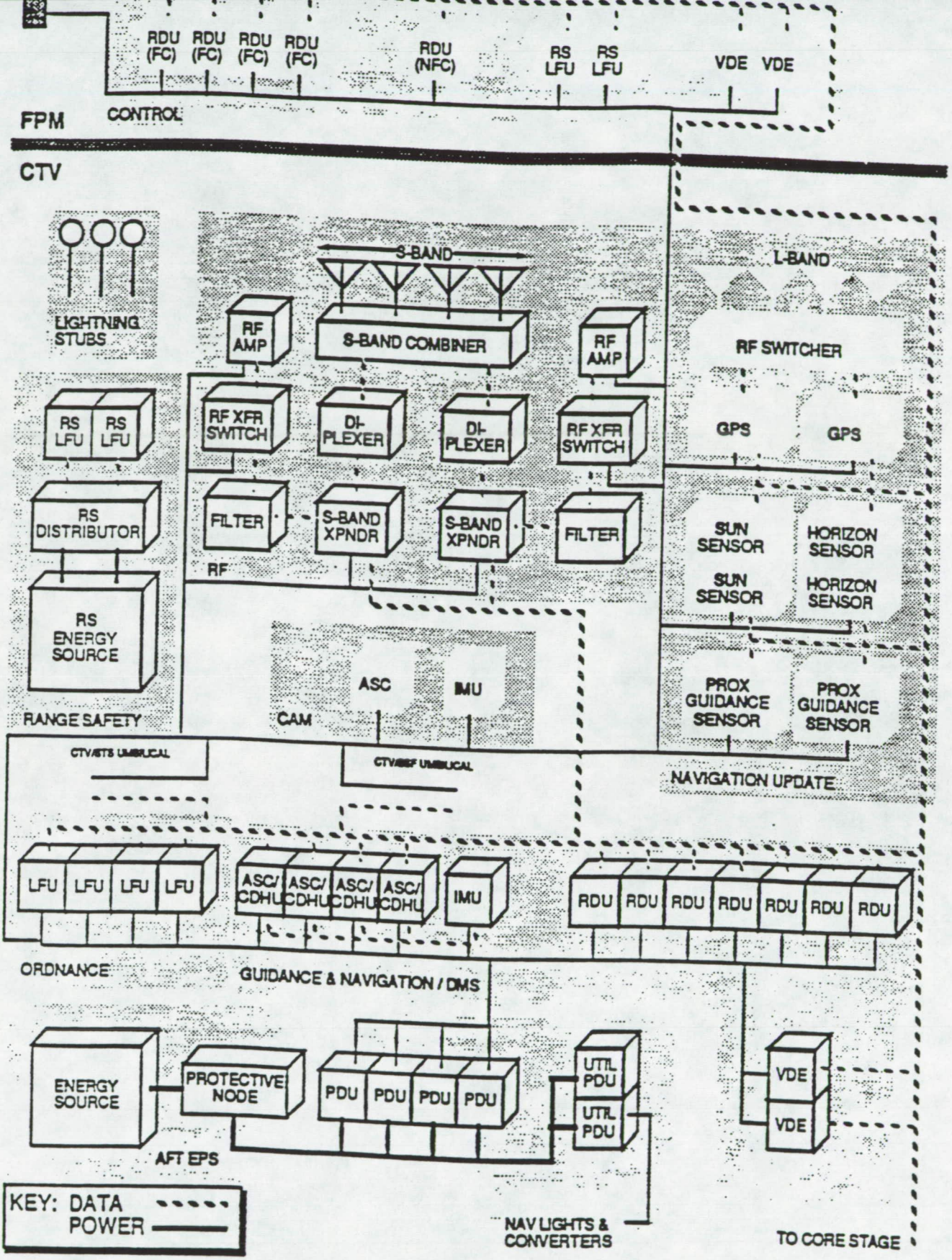


Figure 5.1.5-1: NLS CTV Space Station Freedom Avionics

- NO PAD ACCESS IS THE PRIMARY DRIVER FOR THE FOURTH STRING OF AVIONICS
- COST/BENEFIT TRADES SHOULD BE UNDERTAKEN - AREAS TO CONSIDER
 - PAD ACCESS TO REPLACE FAILED UNITS
 - VEHICLE COMPONENT LAYOUT FOR ACCESSABILITY
 - IMPROVEMENTS IN AVIONICS BOX LEVEL RELIABILITY

2.4 NLS 2-Stage vs. 1.5 Stage Comparison

Task report 2.4 is the result of an USBI evaluation of the MDSSC comparison of the 2-stage vs. 1.5-stage launch vehicle as presented to the MSFC NLS team. The objective was to assess the results presented to MDSSC and to summarize and present to MDSSC any technical issues uncovered. The matrix shown provides the bottom line comparison of the results contained in the MDSSC material. The circled entities indicate the favored value for the associated category. For instance, the 88 Klb payload to LEO for the 2-stage with NLS-3 commonality has a clear advantage over the other two vehicles. The question marks in the matrix indicate areas where no data was presented by MDSSC and are the subject of the observations provided on the next page. The first observation indicates that to complete the comparison story, information must be developed which defines the NLS-3 evolution impacts/costs for the NLS-2 vehicles under consideration. Secondly, cost differentials are attributed to weight delta's without sufficient data to identify where and why this difference accrues.

NLS 2-Stage vs. 1.5-Stage Comparison

Criteria	2-Stage*	2-Stage**	1.5-Stage***	Comment
Total Engines	4 (3/1)	4 (3/1)	5 (4/1)	1.5-Stage, 4 Booster, 1 Sust.
Payload (Klb)	88	50.1	55.7	LEO
Price ($M), T25U	120	105	135	
2nd/Sustainer Str Cost	9	4	25	?
Plumbing Cost	16.5	16.5	22	New vs additional engine?
Engine Cost	26	26	31	Different engines, alt. start?
DDT&E ($B)	2.9	?	3.8	NLS-3 built first
Reliability	0.9781	0.9781	0.982	$480K/flt cost Δ
Program Change	Alt. Start	Alt. Start	None	Not a part of STME program
Operational Efficiency	Less	Less	More	Less elements on 1.5-Stage
2nd/Sustainer Str. Wt (Klbs)	26	7	95	?
Structural Weight (Klbs)	105	35	112.5	?
NLS-3 Price ($M), T25U	?	?	?	Impact on NLS-3 Cost?

* NLS-2, NEO, 88 Klb Vehicle, NLS-3 Commonality
** NLS-2, NEO, 50 Klb Vehicle
*** 1.5-Stage, NEO, 55.7 Klb Vehicle

NLS 2-Stage vs. 1.5-Stage Comparison

Observations

- **NLS-3 Commonality is achieved via the NLS-2, 88 Klb Vehicle and not the NLS-2, 50Klb Vehicle; To get to the Bottom Line One Must Look at the Total System Impact:**
 - **DDT&E for the 2-Stage, 50 Klb Vehicle Option (including NLS-3)**
 - **NLS-3 T25U (How do the different options impact the NLS-3 Cost?)**
- **Major Differences in T25U Cost Attributed to Differences Between 2nd Stage and Sustainer Structural Weight -- Unclear as to Where and Why This Difference Accrues**
- **1.5 Stage Has**
 - **Greater Reliability; $480K/flt Cost Δ Due to Increased Reliability**
 - **No Change to STME Design Required**
 - **More Operational Efficiencies Due to Less Elements; $700K/flt Cost Δ Accrues**

2.5 HLLV/ASRB Compatibility

Task 2.5 is a set of charts presented to Len Worlund on February 19, 1992 summarizing a study of potential incompatibilities of the ASRB with respect to NLS1 (HLLV). The conclusions of this study were (1) utilization of ASRB for NLS1 will require detailed analysis due to induced environment changes, (2) recertification will be required, and (3) SRB electronics are becoming obsolete.



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HLLV/ASRB COMPATIBILITY

Lars Warlund
Rick Bechtel
Bud Wilkerson
Jake Walker
Joey Nimeroff
Jean Thionnet
Wayne Wagner

L. THIONNET
19 FEB 92

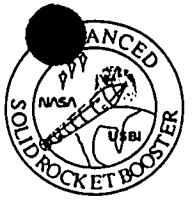


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HLLV/ASRB COMPATIBILITY

AGENDA

- BACKGROUND
- OBJECTIVE
- REUSABILITY
- ENVIRONMENTS
- AVIONICS
- SUMMARY/CONCLUSIONS

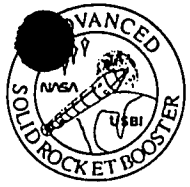


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HLLV/ASRB COMPATIBILITY

BACKGROUND

- STATEMENT: THE ET IS A DIRECTED SUBCONTRACT
- QUESTION: SHOULD NOT THE ASRB BE A DIRECTED CONTRACT?
- STATEMENT: THE ASRB IS TRANSPARENT TO STS AND NLS
- FACT: THERE ARE DIFFERENCES
- EFFORT: HIGH-LIGHT MAJOR DIFFERENCES



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HLLV/ASRB COMPATIBILITY

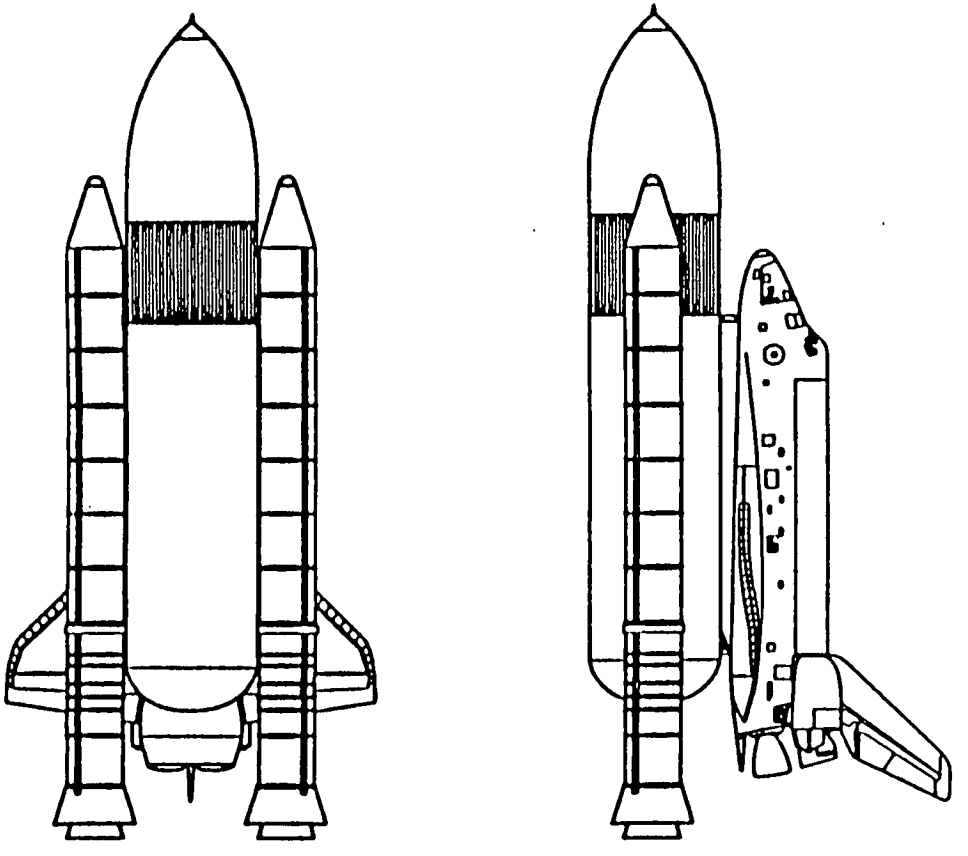
OBJECTIVE

- TO IDENTIFY POTENTIAL INCOMPATIBILITIES OF ASRB WITH RESPECT TO HLLV

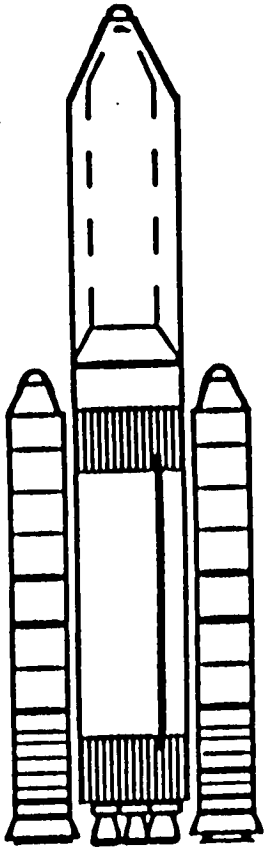
HLLV/ASRB COMPATIBILITY

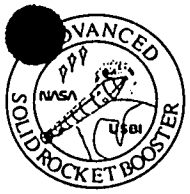
GENERAL OVERVIEW OF VEHICLES

STS



HLLV





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HLLV/ASRB COMPATIBILITY

REUSABILITY

- DEPENDENT ON INDUCED ENVIRONMENTS RESULTING FROM ASCENT AND DESCENT TRAJECTORIES

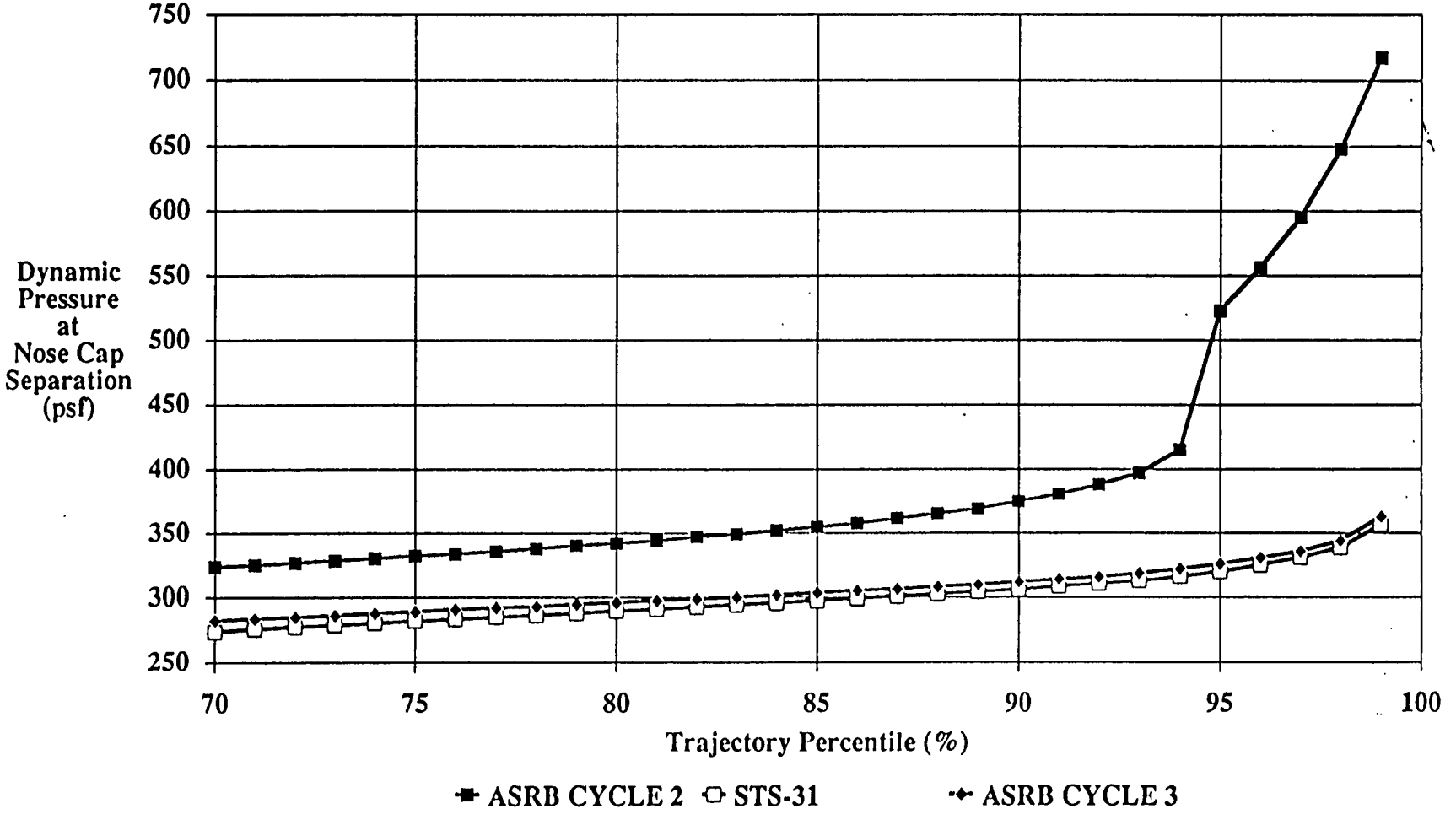
STATE VECTORS AT BOOSTER SEPARATION

	RSRB/SHUTTLE (STS-31)	ASRB/SHUTTLE (CYCLE 3)	ASRB/HLLV (RANGE)	
TIME (sec)	125.8	135.36	131.4 *	
VELOCITY (ft/sec)	4,145	4,956	6,100	6,400
ALTITUDE (ft)	159,670	177,809	153,000	210,000
FLIGHT PATH ANGLE (°)	32.79	27.8	14.2	30.0
APOGEE ALTITUDE (ft)	236,000	265,000	190,000	>300,000

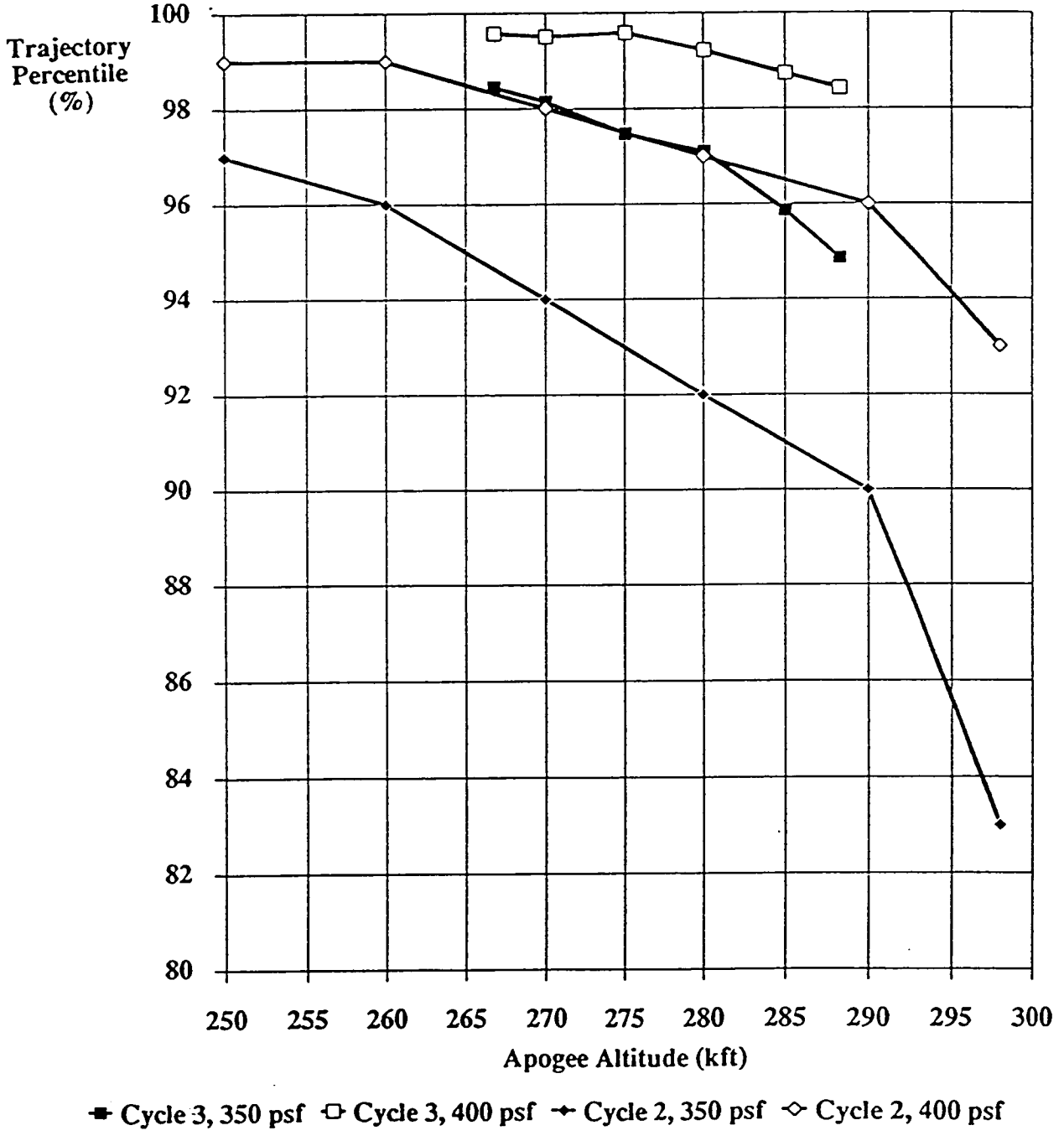
* BURN TIME DIFFERENCE DUE TO MEAN BULK TEMPERATURE OF PROPELLANT (SHUTTLE - 60°F, HLLV - 70°F)

HLLV/ASRB COMPATIBILITY

ASRB NOSE CAP SEP Q COMPARISON
Nozzle On

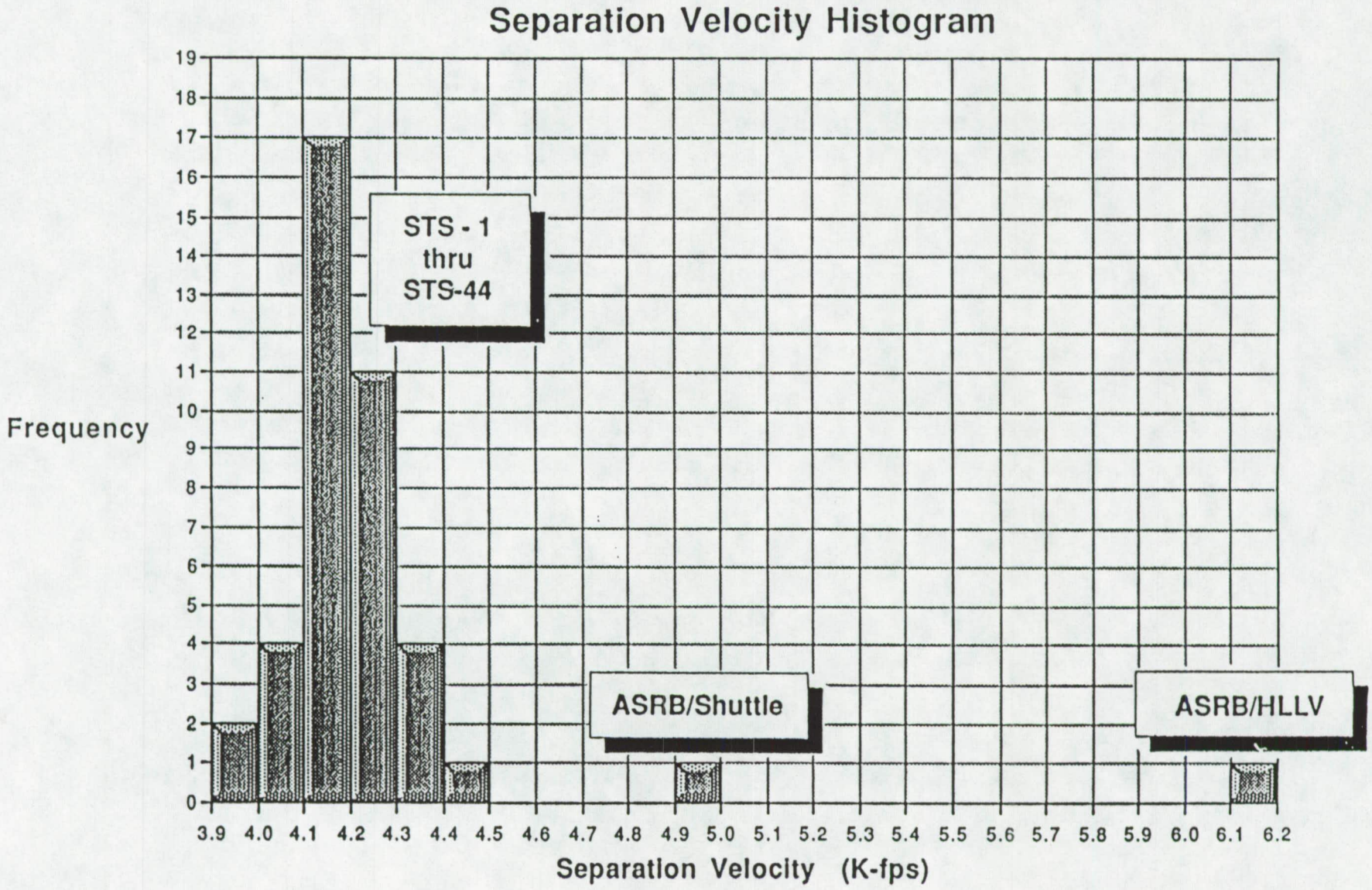


ASRB APOGEE SENSITIVITY
"Cycle 3" Trajectories at Nose Cap Separation
Weight at Max Q Descent: 182171 lb X C.G.: 1264 in

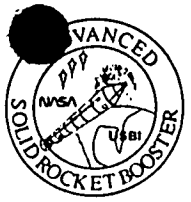


LTO-92/AJ

HLLV/ASRB COMPATIBILITY



LT021992/AJ



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HLLV/ASRB COMPATIBILITY

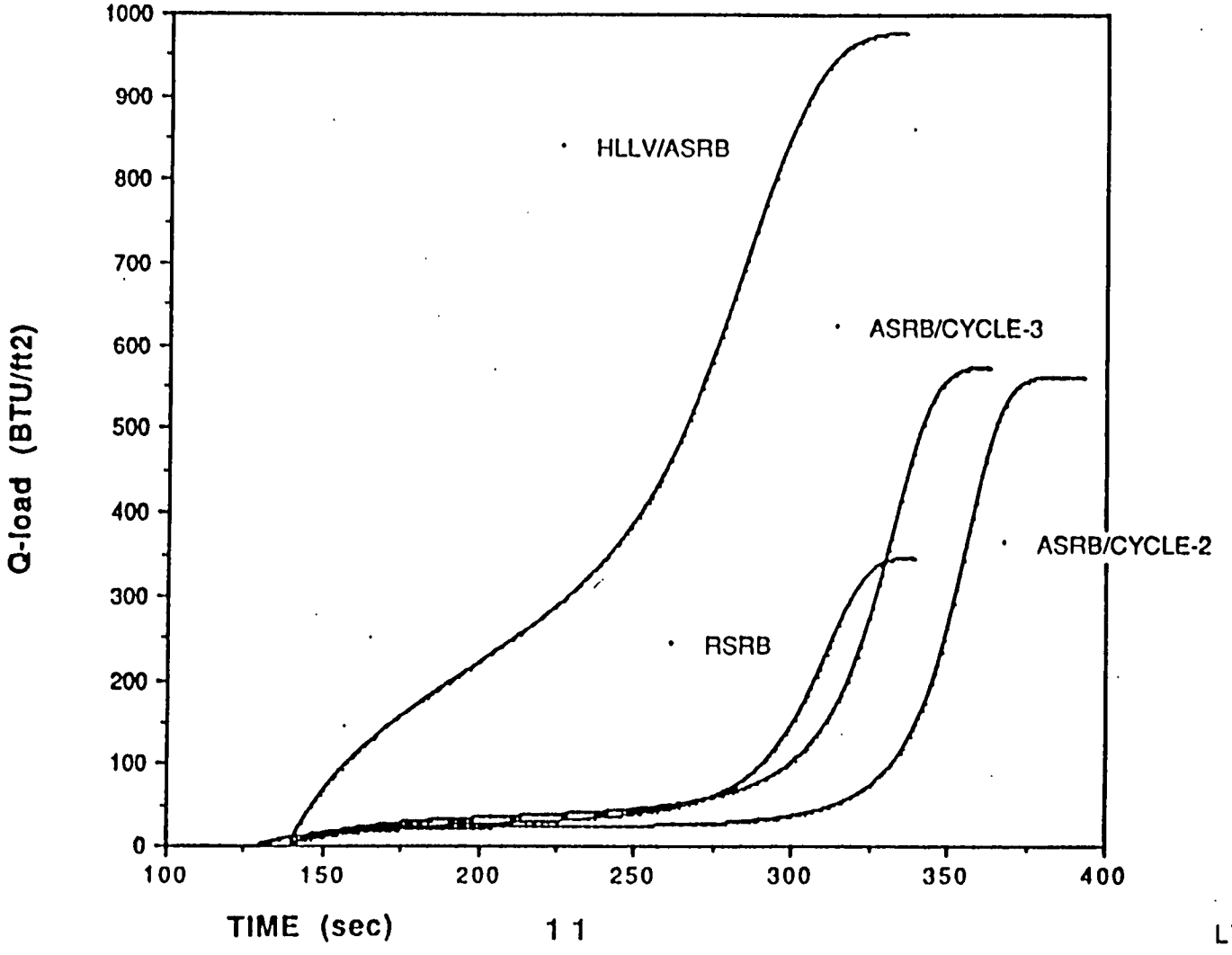
HLLV INDUCED ENVIRONMENTS

- O PRELAUNCH/LIFT OFF LOADS ARE DIFFERENT
- O THERMAL ENVIRONMENTS ARE DIFFERENT
 - ENGINE ARRANGEMENT (CLOSER PROXIMITY TO STMEs)
 - ENGINE TYPE (GREATER MASS FLOW PER ENGINE)
 - HOTTER ASCENT TRAJECTORY
 - HOTTER DESCENT TRAJECTORY
- O ACOUSTIC
 - ASCENT VIBRO-ACOUSTICS MORE SEVERE
 - DESCENT VIBRO-ACOUSTICS MORE SEVERE

HLLV/ASRB COMPATIBILITY

DESCENT INDUCED ENVIRONMENTS

Heating Load Indicator
95% Heating Trajectories



LT021992/AJ

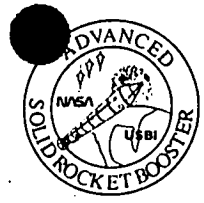


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HLLV/ASRB COMPATIBILITY

AVIONICS

- GUIDANCE AND CONTROL SUBSYSTEM
- EVENT SEQUENCER
- COMMUNICATIONS
- RANGE SAFETY
- OBSOLETE SRB ELECTRONICS



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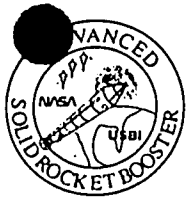
HLLV/ASRB COMPATIBILITY

SRB HARDWARE IMPACTS

ASCENT TRAJECTORY

	STS RSRB TO ASRB			HLLV* QUICKLOOK ASRB IMPACTS	
SUBSYSTEM	CHANGE REQ'D	POTENTIAL CHANGE	BASIS FOR CHANGE	ADEQUATE	ASSESSMENT REQUIRED
• TVC		√	NOZZLE TORQUE	√	
• DECELERATOR			VIBRO-ACOUSTIC INOPERATIVE DURING ASCENT		√
• STRUCTURES					
- AFT SKIRT		√	F.O.S. IMPROVEMENT (MODIFICATION IN WORK)		√
- STRUTS	√		ASRM DIAMETER DELTA (DIAGONAL ONLY)	√	
- STRUT CLOSEOUTS	√		INTEGRAL RING VERSUS BOLT ON	√	
- FWD ASSEMBLY		√	VIBRO-ACOUSTICS, REENTRY AERO		√
- SYSTEMS TUNNEL	√		ASRM CONFIGURATION, VENTING, HEATING		√
• TPS					
- THERMAL CURTAIN			IGNITION OVERPRESSURE (NO IMPACT FOR ASRB)		√
- AFT SKIRT ACREAGE			PLUME HEATING		√
• E&I			VIBRO-ACOUSTICS, IEA RELOCATION		√
• RSS			AFT SEGMENT BREAKUP, VIBRO-ACOUSTICS		√
• DFI	√		MEASUREMENT REQUIREMENTS, VIBRO-ACOUSTICS		√
• SEPARATION					
- BSM				√	
- PYRO	√		ASRM IGNITION - INITIATION	√	

* MAY 91 REF. DEFINITIONS & CONSTRAINTS



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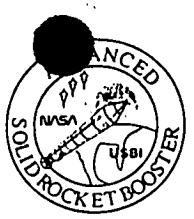
HLLV/ASRB COMPATIBILITY

SRB HARDWARE IMPACTS

DESCENT TRAJECTORY

	STS RSRB TO ASRB			HLLV* QUICKLOOK ASRB IMPACTS	
SUBSYSTEM	CHANGE REQ'D	POTENTIAL CHANGE	BASIS FOR CHANGE	ADEQUATE	ASSESSMENT REQUIRED
• TVC		√	RE-ENTRY AEROHEATING		√
• DECELERATOR			HIGH Q & VELOCITY DEPLOYMENT (NOSE CAP SEP.), DROGUE CHUTE G LOADING, DROGUE HANG TIME, MAIN CHUTE HANG TIME (CYCLE 3 DATA)		√
• STRUCTURES					
- AFT SKIRT	N/A	N/A	DESIGNED TO PRELAUNCH LOADS	√	
- STRUTS	N/A	N/A		√	
- STRUT CLOSEOUTS	N/A	N/A		√	
- FWD ASSEMBLY		√	HIGH Q RE-ENTRY, DECELERATOR, AERO-LOADS		√
- SYSTEMS TUNNEL	√	√	ASRM CONFIGURATION, HIGH Q REENTRY, VENTING, HEATING		√
• TPS					
- THERMAL CURTAIN		√	REENTRY AEROHEATING, FLUTTER DYNAMICS		√
- AFT SKIRT ACREAGE	N/A	N/A	DESIGNED BY ASCENT, BEING ASSESSED FOR REENTRY		√
• - INTERNAL AFT SKIRT INSULATION		√	BEING ASSESSED FOR REENTRY THERMAL ENVIRONMENT		√
• E&I		√	VIBRO-ACOUSTICS - ASSESS FOR REUSE, IEA RELOCATION		√
• RSS		√	VIBRO-ACOUSTICS - ASSESS FOR REUSE		√
• DFI	√	√	MEASUREMENT REQUIREMENTS, VIBRO-ACOUSTICS		√
• SEPARATION					
- BSM	N/A	N/A		N/A	N/A
- PYRO		√	VIBRO-ACOUSTIC (SEPARATION ORDNANCE RING) - TO BE ASSESSED		√

* MAY 91 REF. DEFINITIONS & CONSTRAINTS



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HLLV/ASRB COMPATIBILITY

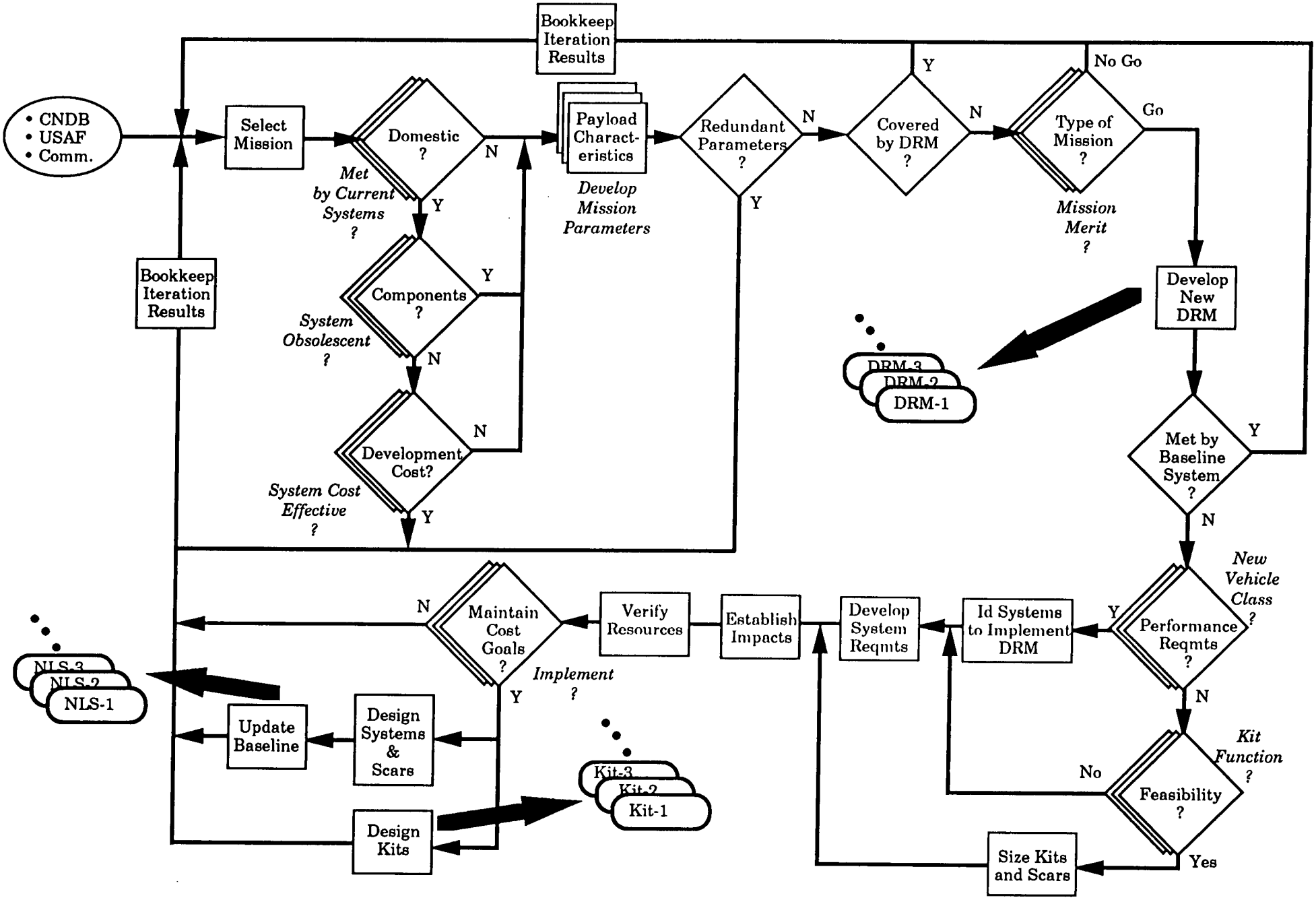
SUMMARY/CONCLUSIONS

- O UTILIZATION OF ASRB FOR HLLV WILL REQUIRE DETAILED ANALYSIS/ASSESSMENT DUE TO INDUCED ENVIRONMENT CHANGES
 - VIBRO-ACOUSTICS
 - THERMAL
 - AERODYNAMIC
- O STS FLEET HARDWARE CERTIFICATION
 - HLLV INDUCED ENVIRONMENTS OUTSIDE OF QUALIFICATION LIMITS
 - RECERTIFICATION/REQUALIFICATION FOR REUSE WILL BE REQUIRED
- O SRB ELECTRONICS OBSOLESCENCE

2.6 Architecture Definition Process

Task 2.6 is an architecture definition process, which provides a systematic means for defining a justifiable set of NLS vehicles by first, developing a set of design reference missions (DRMs) and then, determining if these DRMs are met by the NLS baseline, or if a new vehicle class is needed, or if kits or scars for the baseline need to be designed. An accompanying set of notes is provided to further define the criteria implemented in the process.

Architecture Definition Process



Architecture Definition Process Notes

A. Mission Parameters

1. Payload Characteristics
 - a. Mass
 - b. Dimensions
 - c. Accommodations
 - d. GSE/ASE
 - e. Security
 - f. Storables
2. Mission Characteristics
 - a. Orbital Parameters
 - b. Duration
 - c. Events
 - d. Special Considerations
 - i. Manned
 - ii. Rendezvous
 - iii. Sun Synchronous
 - iv. Pointing Requirements

B. Mission Merit Criteria

1. Type of Mission - Scientific, National Security, Commercial, etc.
2. Cost versus Payback
3. Intangibles - Political, Social, Public Relations
4. Building Block to future research or missions

C. Current Systems

1. Domestic
 - a. Scout
 - b. Pegasus
 - c. Taurus
 - d. Delta
 - e. Titan
 - f. Atlas
 - g. STS

2. Foreign
 a. Ariane
 b. ASLV, PSLV
 c. Shavit
 d. Long March
 e. H-1/2
 f. Zenit
 g. Proton
 h. SL-17
 i. Energia

D. Obsolescent

1. Components
2. Technologies

E. System Cost Effective

1. Development
2. Recurring
2. Life Cycle

F. Kit Function?

1. Feasibility
2. Usage Factor
3. Cost of Kit/Scar

2.7 50K Vehicle Justification

Task 2.7 is a set of charts USBI developed to examine the justification for the NLS 50K vehicle. USBI initiated this task by synopsizing the NLS opportunity in terms of the current launch vehicle environment, i.e., the NLS program objectives, potential customers (mission model), the entities that comprise the US space infrastructure, technologies, current and proposed US and foreign systems, and flight-proven US and foreign engines and motors. Then, USBI developed a definition process which begins with a mission model as input, proceeds through a series of steps which results in a set of NLS missions, vehicle categories, time phasing, and cost requirements. With regard to the mission model, USBI summarized applicable data from the MDSSC NLS Payload Requirements Database in an attempt to identify payload categories in which needs exist. The NLS program "guidelines" were traced to their root source in an attempt to establish an authoritative list of program requirements. This list was to be assessed versus current/proposed launch systems, both domestic and foreign, to address the issue of justification for the 50K vehicle.

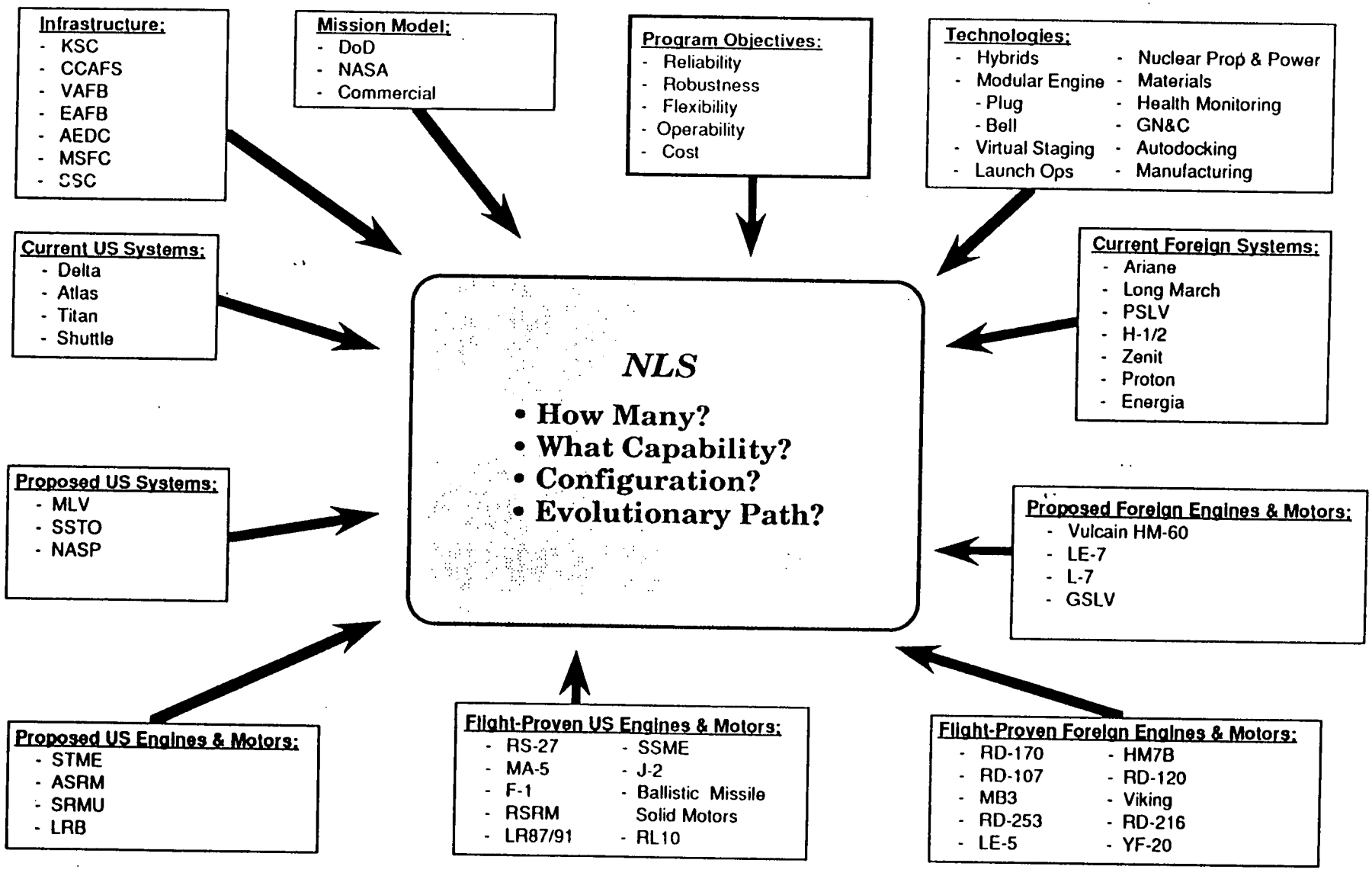
Agenda

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- The NLS Opportunity
- Justification for 50K Vehicle
 - Definition Process
 - Payloads Database
 - Program Guidelines
 - Systems Assessment
 - Justification
- 20K Vehicle Implementation & Utilization
 - Definition Process
 - Missions (Utilization)
 - Systems
 - Implementation
- Summary

The NLS Opportunity

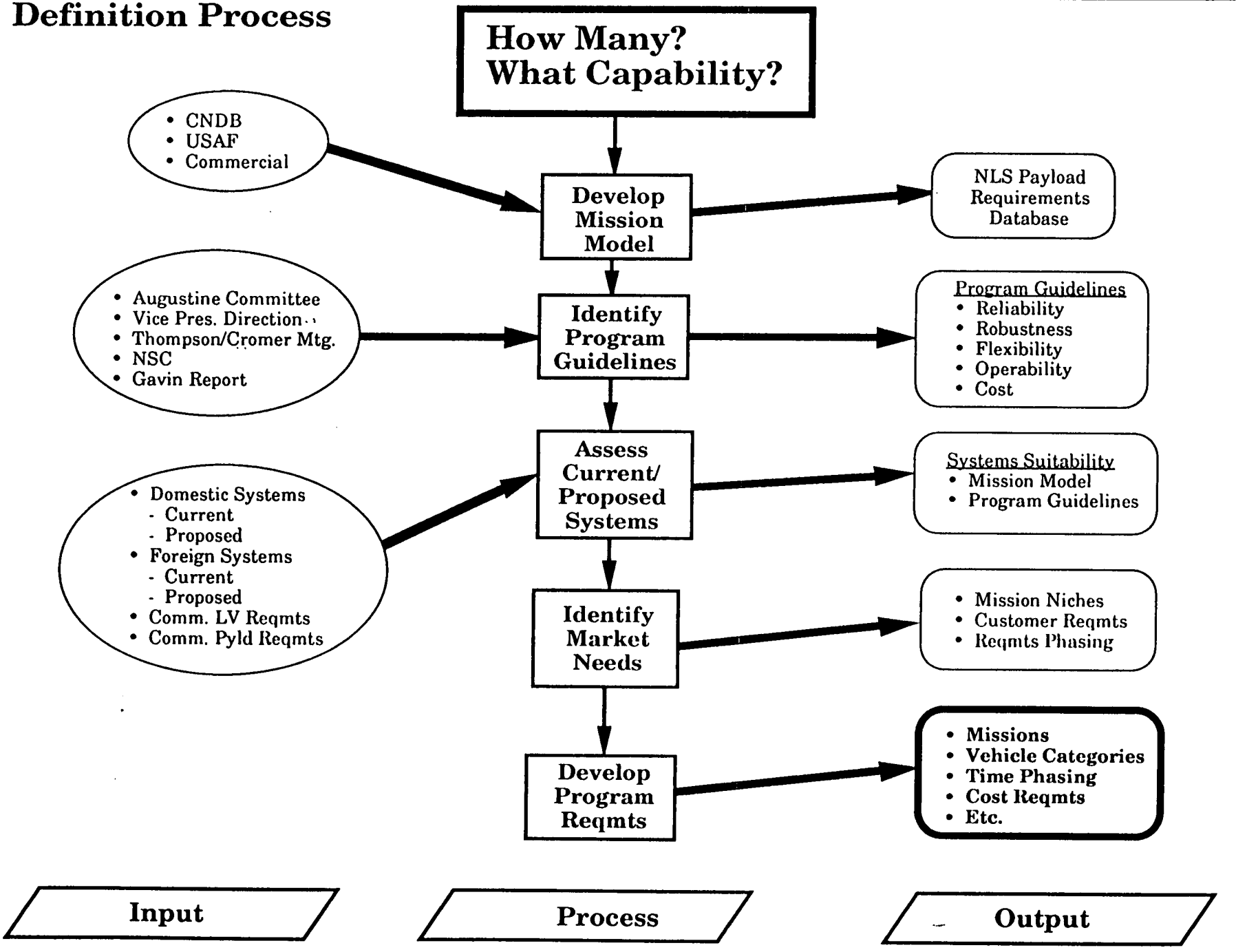
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Justification for 50K Vehicle

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Definition Process



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Mission Model (1990 - 2020)

MDSSC NLS Payload Requirements Database

Utilization	Mass to Leo (Klbs)*												Mission**								
	<4	4-8	8-10	10-15	15-20	20-30	30-40	40-70	70-100	330	600	TBD	LEO	GTO	GEO	SSF	US Orbit	Deep Space	Lunar	Mars	TBD
Air Force	0	95	0	30	46% 145	87	5	28% 138	0	0	0	0	0	36% 190	60	0	52% 275	0	0	0	0
NASA	40	55	8	10	5	85	49% 35	30	0	30	5	5	16% 45	0	30	17% 50	31% 90	8	17% 50	15	2
Commercial	20	80	2	51% 115	65	30	20	2	0	0	0	20	5	93% 515	20	0	15	0	0	0	0
Total	60	230	10	155	215	202	60	170	0	30	5	25	50	705	110	50	380	8	50	15	2

* Low Commercial Growth Weight Model, Discounted 50%

** Commercial High Growth Weight Model, No Discount

Program Guidelines

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Guideline	Augustine	VP Dir.	JR/Cromer	NSpC Dir.	NSpC Mtg.
Joint Program/Funding		X	X	X	*
Approximate $10B Program			X		X 11.4B
Low Recurring Cost		X	X	X	*
Shuttle Derived			X	X	
Titan Shroud			X	X	
STME			X	X	
Common Core			X	X	
No Solid (Castors)			X	X	
20K Vehicle					X
Upper Stage			X	X	
Facility Capability at KSC			X	X	
Facility Capability at CCAFS			X	X	
Advanced Development Program (New Techn.)	X	X	X	X	
Operability (Reduce Ops Cost)	X	X	X	X	*
Engine Out			X	X	
No Altitude Start			X	X	
Man-Rateable	X	X	X	X	
Off-Load Shuttle	X		X	X	
Off-Load Titan			X	X	
Evolve	X	X	X	X	
Commercial				X	
CTV			X	X	
Provide a Range of Capability including HLLV	X	X	X	X	*
Improve Fieldability			X	X	
Improve Responsiveness			X	X	
Improve Mission Performance			X	X	
First Flight				1999	2002

* **Reaffirmed 4/16/91 Direction**

Justification for 50K Vehicle

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Systems Assessment

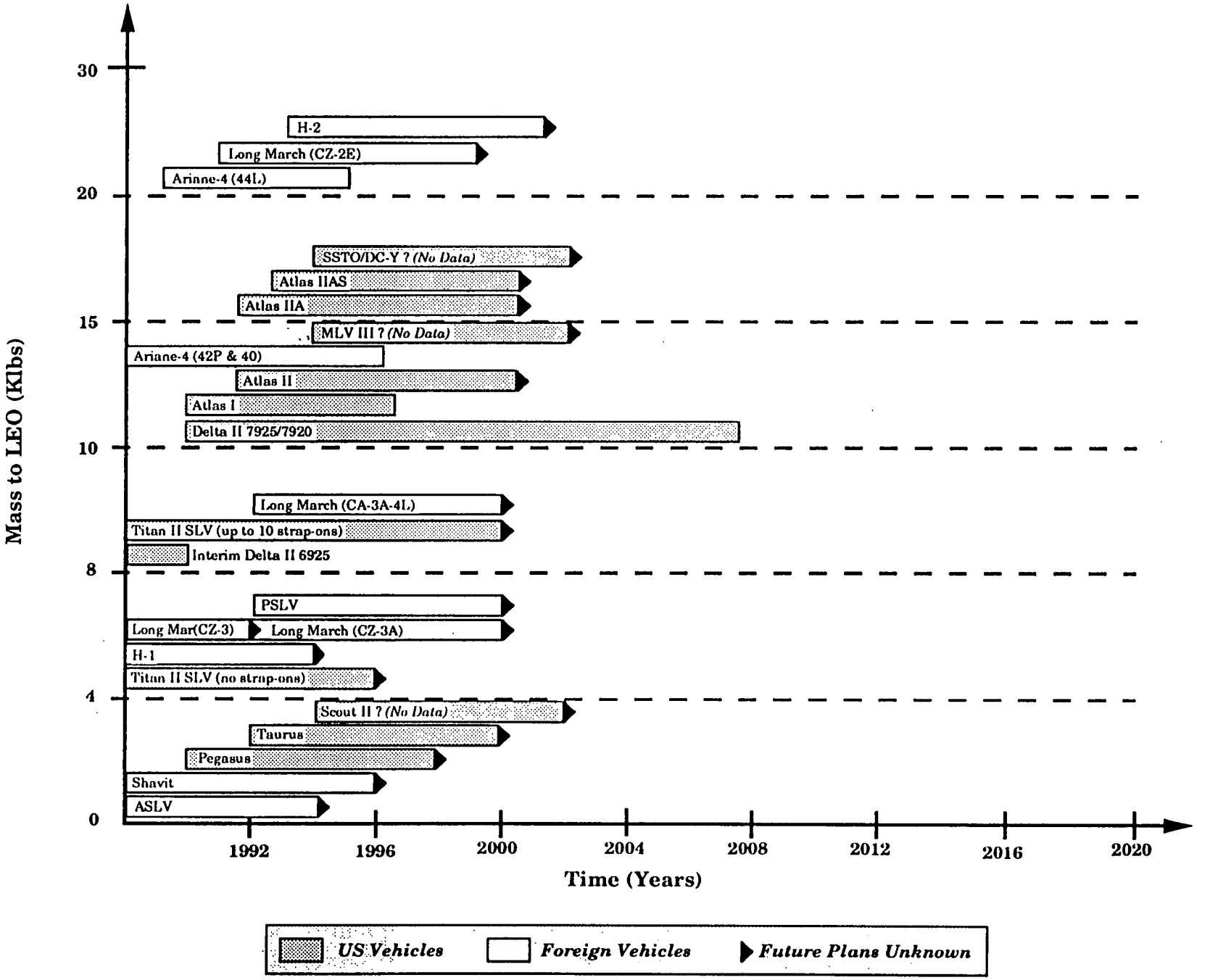
		Mass to LEO (Klbs)										
		< 4	4 - 8	8 - 10	10-15	15-20	20-30	30-40	40-70	70-100	330	600
U S	Current	• SC ('79) • PG ('90)	• TII ('88)	• TII (TBD)	• DII ('90)	• AII ('91) • AIIA ('91)		• TIII ('89)	• TIV ('89) • TIV('89) • STS('89)			
	Proposed	• TA ('92)			• MLV(TBD)	• AIIAS('93) • SSTO(TBD)						
Foreign	Current	• ASLV ('87) • S ('88)	• CZ-2C ('75) • PSLV ('92)	• H1 ('86)	• A4-40('88)	• A4-42P('88)	• A4-44L('89) • CZ-2E('90)	• Z2('85)	• P('67)		• E('87)	
	Proposed						• H2('93)		• A5('95) • A5/H('02)			

Mission Requirements

Utilization	Mass to Leo (Klbs)											
	< 4	4-8	8-10	10-15	15-20	20-30	30-40	40-70	70-100	330	600	TBD
Current US Systems:	•Scout ! •Pegasus •Taurus	•Delta 3920/PAM-D •Titan II SLV (no strap-ons)	•Interim Delta II 6925 •Titan II SLV (up to 10 strap-ons)	•Atlas I •Atlas II •Delta II 7925/7920	•Atlas IIA		•Titan III •Titan IV (SRM)	•STS				
Proposed US Systems:	•Scout II			•MLV III	•Atlas IIAS •SSTO- DC-Y			•Titan IV (SRMU)				
Current Foreign Systems:	•Ariane I •ASLV •Shavit	•Ariane II •Ariane III •Long March (CZ-2 & 2C) •PSLV •H-1 •Long March (CZ-3 & 3A)	•Long March (CZ-3A-4L)	•Ariane IV (40) •Ariane IV (42P)		•Ariane IV (44L) •Long March (CZ-2E) •H-2	•Zenit-2	•Proton		•SL-17 Energia		
Proposed Foreign Systems:							•Ariane V	•Ariane V /Hermes	•SL-15 Energia M			

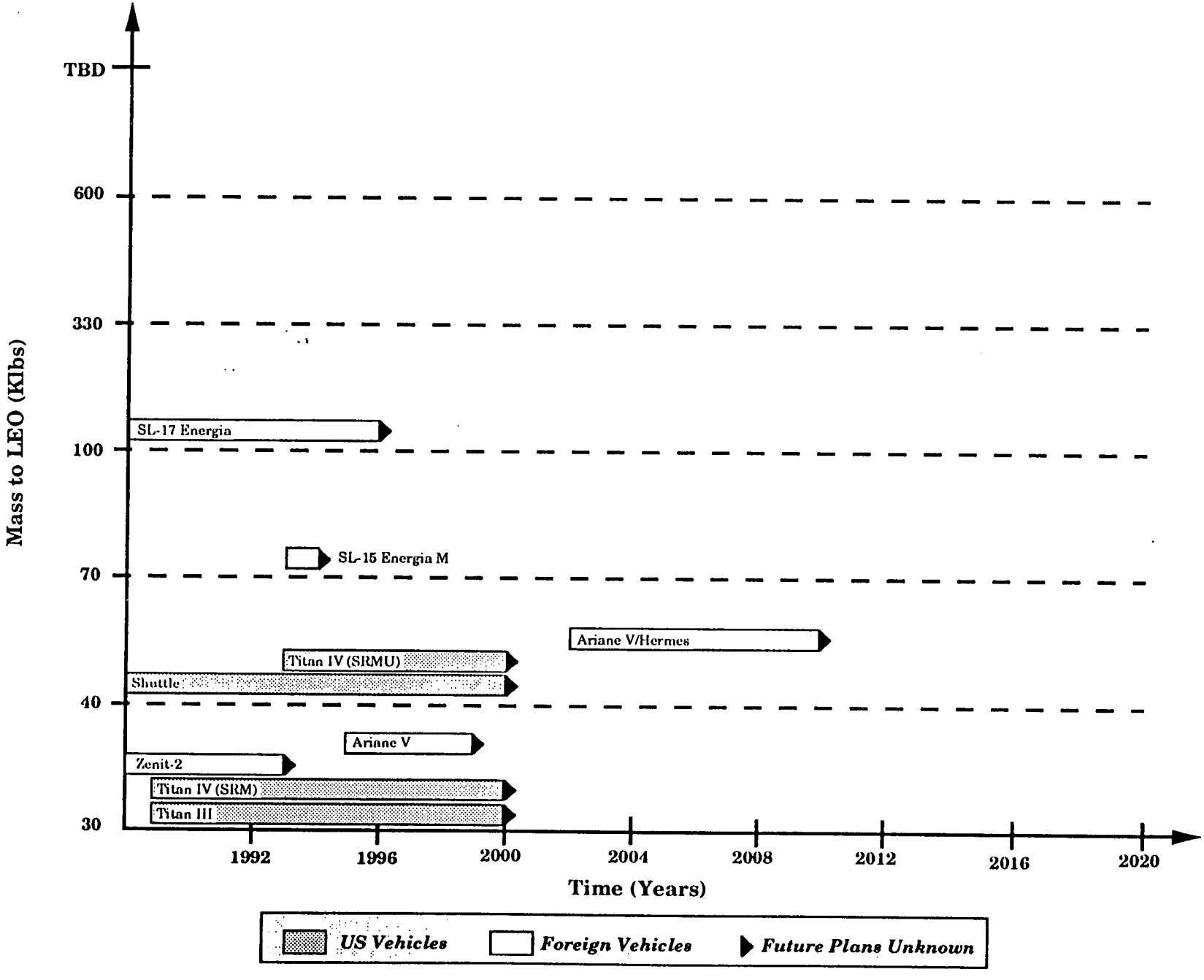
Mission Requirements

Mass to LEO versus Time



Mission Requirements

Mass to LEO versus Time



Justification for 50K Vehicle

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Systems Assessment

Guideline	Delta	Atlas	Titan	STS	MLV	SSTO	Ariane	Long March	PSLV	H-1/2	Zenit	Proton	Energia	Comments
Joint Program/Funding														Not Applicable
Approximate $10B Program														
Low Recurring Cost														
Shuttle Derived														
Titan Shroud														
STME														
Common Core														
No Solid (Castors)														
20K Vehicle														
Upper Stage														
Facility Capability at KSC														
Facility Capability at CCAFS														
Adv. Development Pgm														
Operability (Reduce Ops Cost)														
Engine Out														
No Altitude Start														
Man-Rateable														
Off-Load Shuttle														
Off-Load Titan														
Evolve														
Commercial														
CTV														
Range of Capability														
Improve Fieldability														
Improve Responsiveness														
Improve Mission Performance														
First Flight														

● - Exceeds Reqmt
⊖ - Meets Reqmt
○ - Does not meet Reqmt

2.8 Systems Engineering and Integration

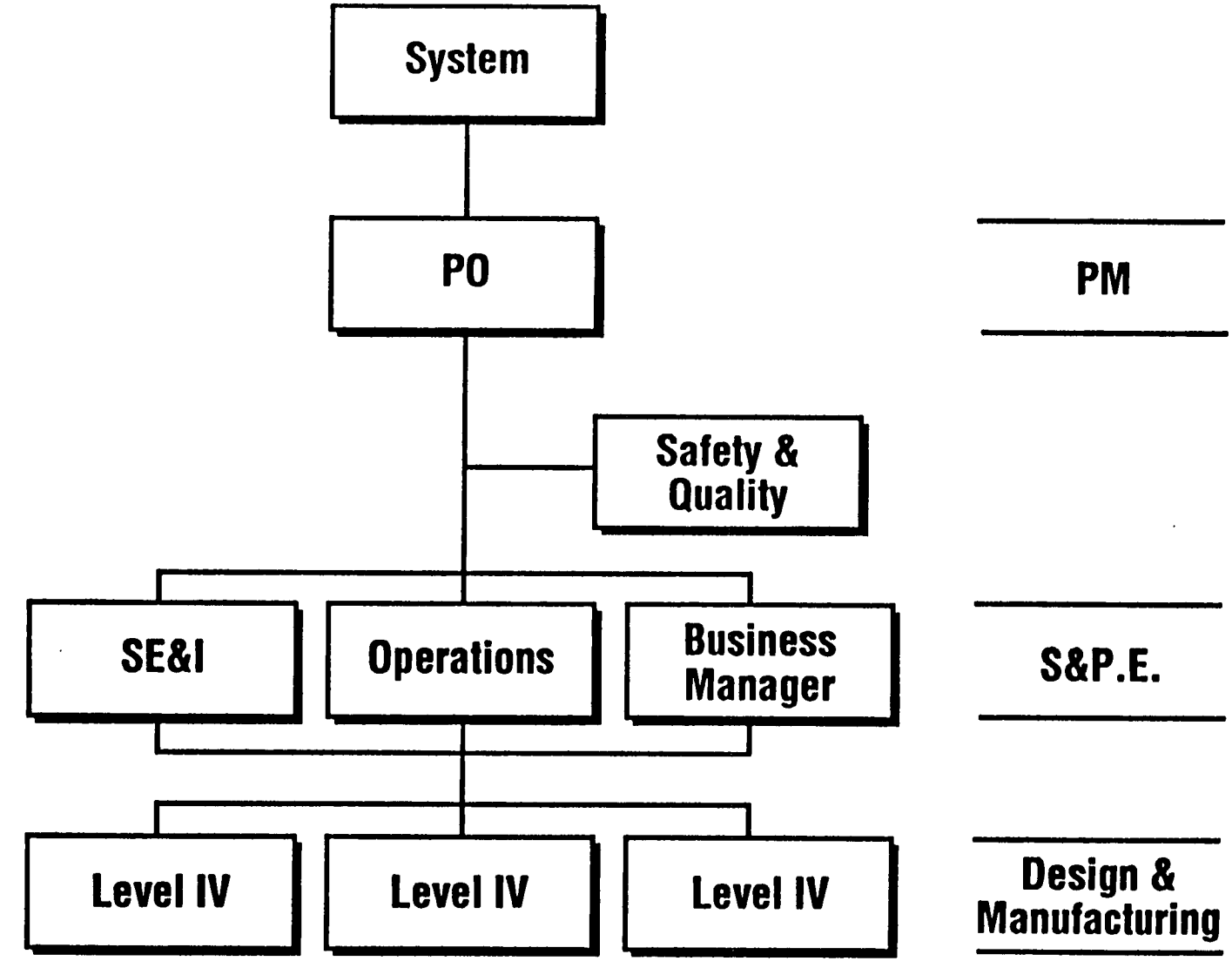
Task 2.8 is a set of Systems Engineering and Integration charts describing the major functions, the elements, and the products of an SE&I organization. Also, included in this report is a detailed list of tasks for Systems Engineering, Systems Integration, and System Verification; and, a critical skills estimate matrix.

Systems Engineering & Integration

Organization and Responsibilities

Systems Engineering and Integration

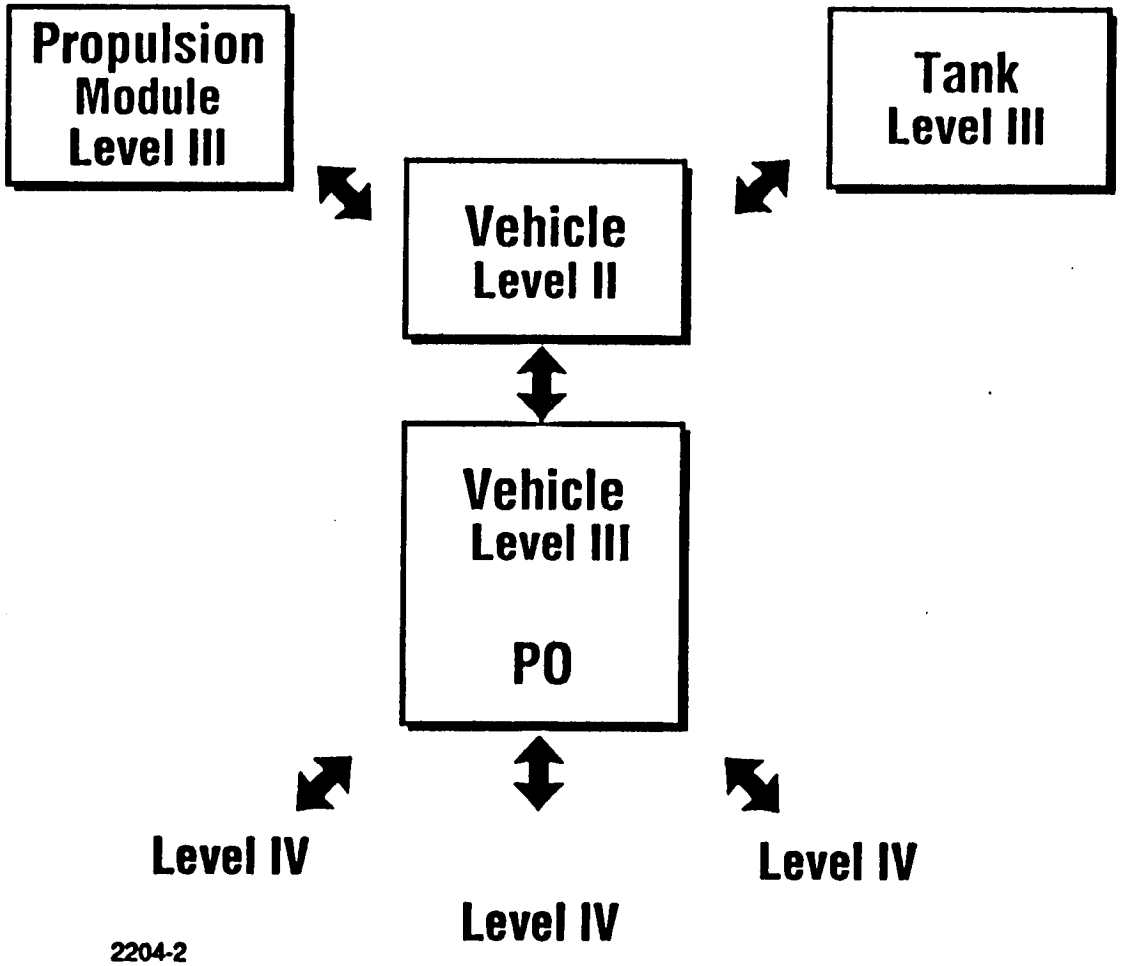
Major Functions—Organization



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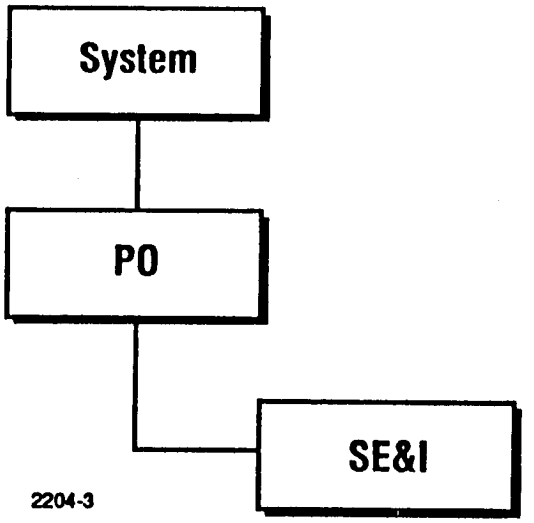
Systems Engineering and Integration

Major Functions—SE&I



Systems Engineering and Integration

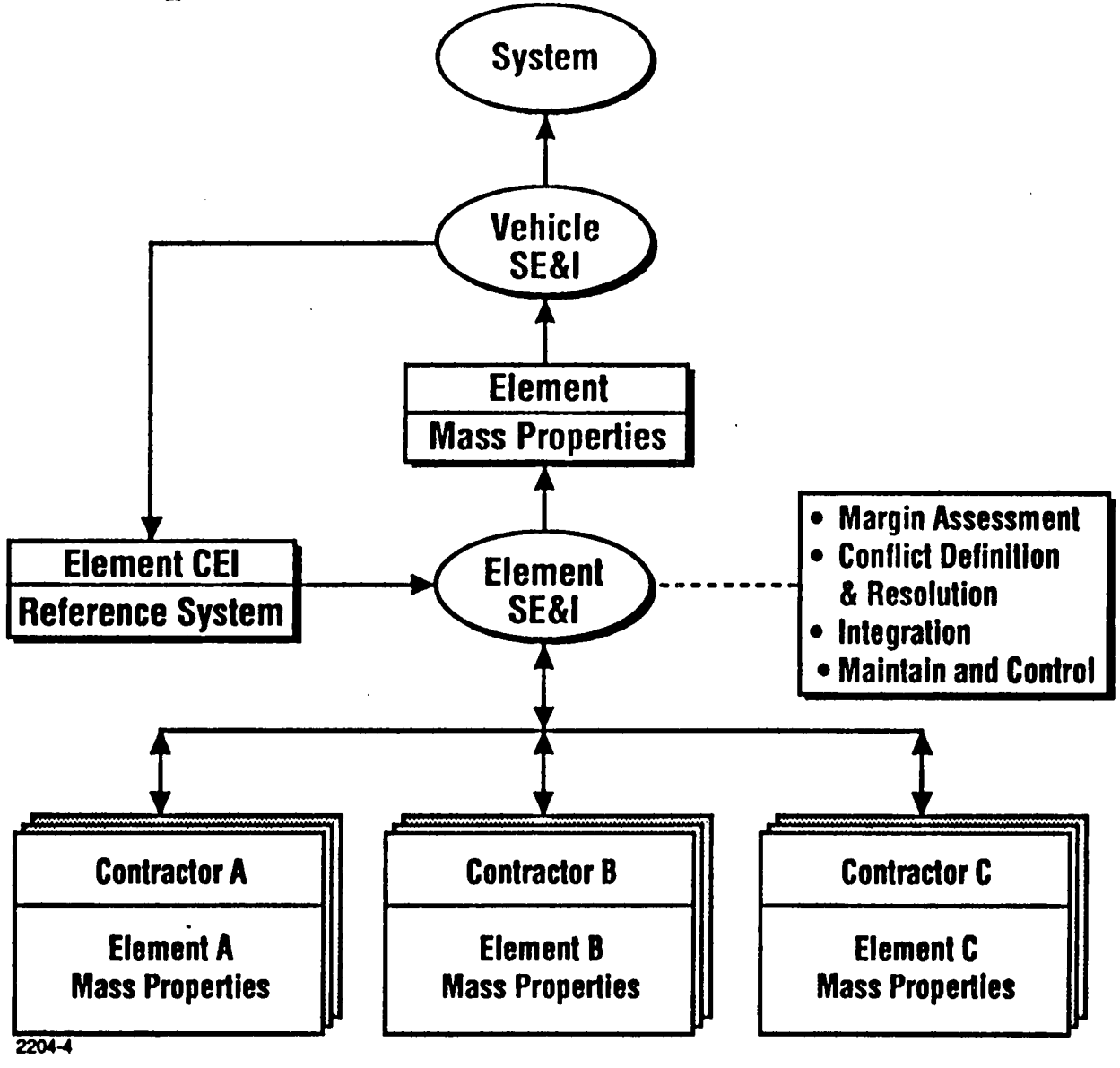
Major Functions—SE&I



- Interpret System Requirements; develop derived requirements
- Provide oversight of requirements implementation
- Perform System Design Optimization; provide system trade studies and analysis of subsystem performance
- Assess integrated system performance
- Assess critical hardware and software anomalies, trends, etc.
- Risk management
- Provide technical assessment of change requests

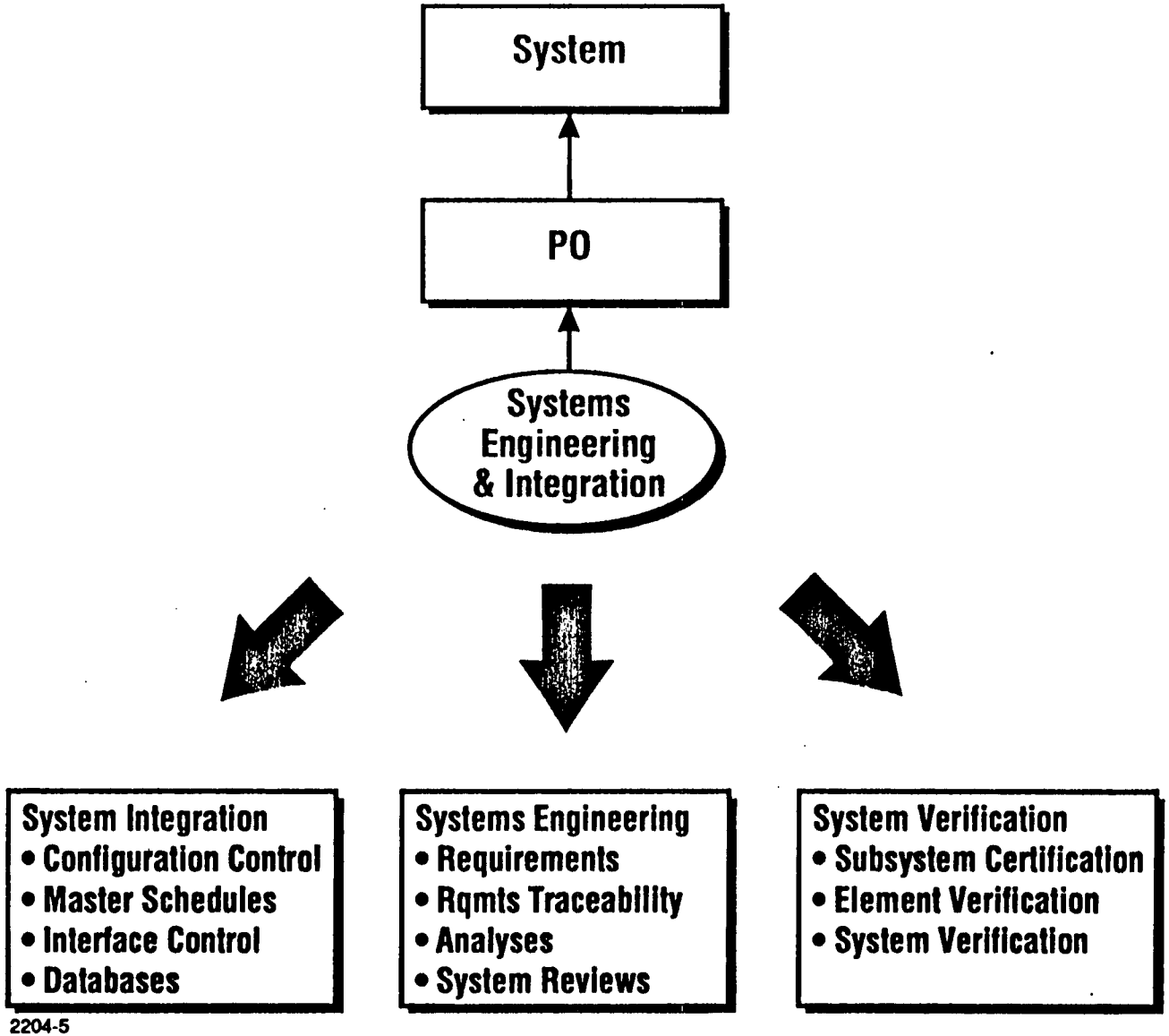
Systems Engineering and Integration

SE&I Task Example



Systems Engineering and Integration

SE&I Elements

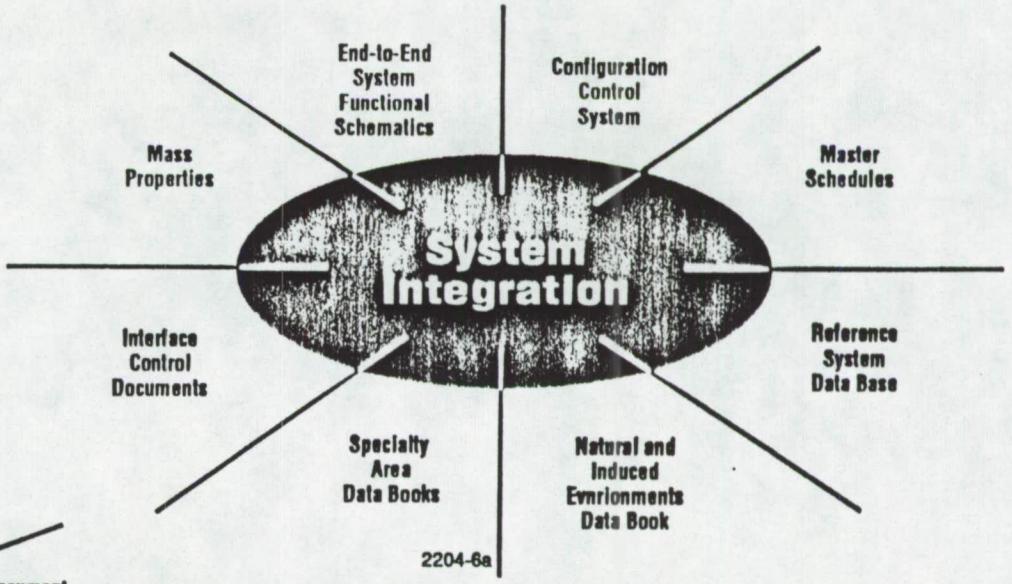


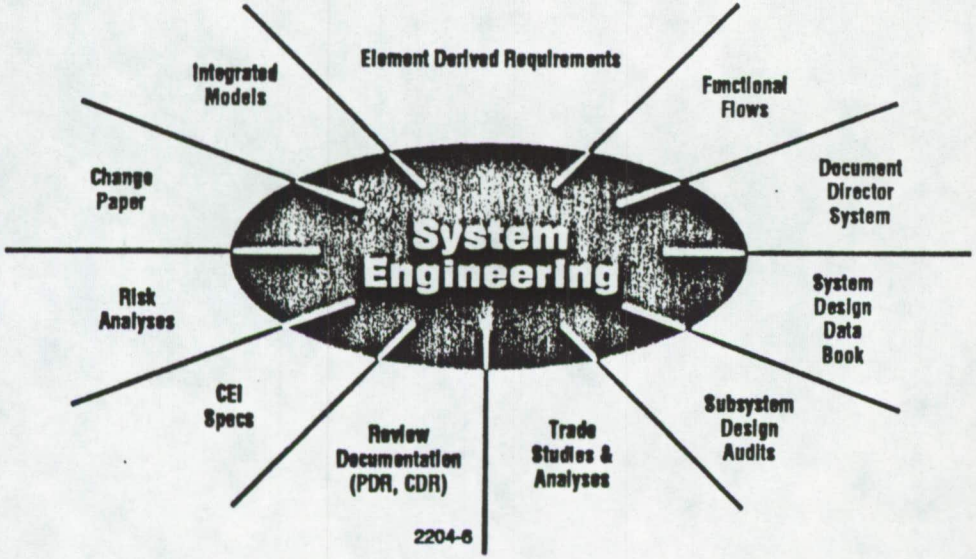
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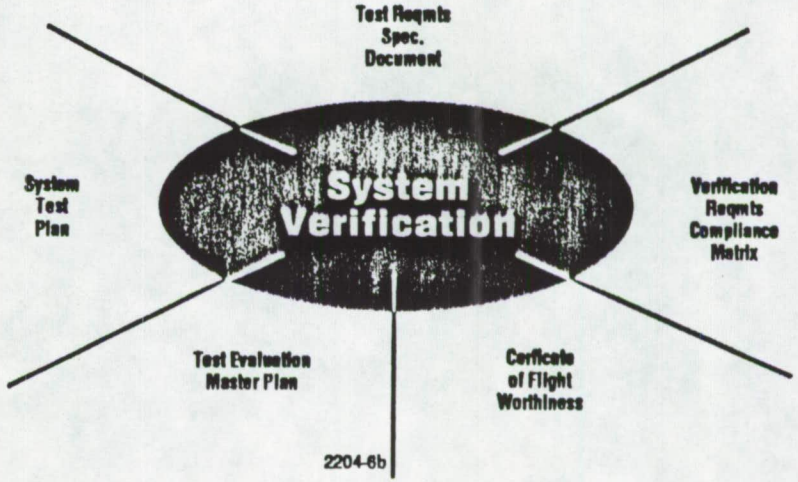
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Systems Engineering and Integration

SE&I Products







2204-100

Systems Engineering and Integration

System Engineering (SE)

- **Requirements (R)**
 - **System requirements maintenance and control**
 - **Definition and allocation of derived requirements**
 - **CEI maintenance and control for each element**
- **Requirements Traceability (RT)**
 - **System requirements traceability**
 - **Derived requirements traceability**
 - **Change control traceability**
- **Analyses (A)**
 - **Establish and maintain integrated model for system performance analysis (structural, transient response, etc.)**
 - **System design optimization studies and trade-offs**
 - **Conflict definition and resolution involving risk, performance, cost, schedule, margins, and anomaly impacts**
 - **Analyze requirements and develop rationale for changes**
 - **Risk analysis, management**
- **System Reviews (SR)**
 - **Staff reviews and change proposals**
 - **Prepare change paper**
 - **Requirements audit**

Systems Engineering and Integration

System Integration (SI)

- **Configuration Control (CC)**
 - **WBS maintenance and control**
 - **Configuration identification, control, change status, accounting, verification, and audit**
 - **Establish, maintain and control reference system database and released drawings, and configuration change proposals/orders**
- **Master Schedule (MS)**
 - **Establish, maintain and control engineering master schedule**
 - **Establish, maintain and control hardware availability schedule**
 - **Establish, maintain and control test schedule**
- **Interface Control (IC)**
 - **Establish, maintain and control element to element ICDs**
 - **Establish, maintain and control element to vehicle ICDs**
 - **Establish, maintain and control vehicle to system ICDs**
 - **Oversight of assembly sequence**
- **Data bases (DB)**
 - **Establish, maintain and control natural environment data books**
 - **Establish, maintain and control induced environment data books including; Acoustics, thermal, dynamics, loads, etc..**
 - **Establish, maintain and control data books for speciality areas including risks, hazards, mass properties, reliability, safety, critical items, FMEA, etc.**

Systems Engineering and Integration

System Verification (SV)

- **Subsystem Certification (SC)**
 - **Establish, maintain and control subsystem certification plans**
 - **Review and approve plan changes**
 - **Review and validate verification results**
- **Element Verification (EV)**
 - **Establish, maintain and control element verification plans**
 - **Review and approve plan changes**
 - **Review and validate verification results**
- **Vehicle Verification (VV)**
 - **Establish, maintain and control vehicle verification plans**
 - **Monitor and approve plan changes**
 - **Monitor and validate verification results**
- **System Verification (SV)**
 - **Establish, maintain and control system verification plans**
 - **Monitor and approve plan changes**
 - **Monitor and validate verification results**

Systems Engineering and Integration

SE&I Critical Skills Estimate

		Skill Categories							
Function	Manpower	SSE	SE	SA	Anal.	Eng	SSI	SI	Data Spec.
• System Engineering									
– Requirements									
– Requirements Traceability									
– Analyses									
– System Review									
• System Integration									
– Configuration control									
– Master schedule									
– Interface control									
– Databases									
• System Verification									
– Subsystem Certification									
– Element Verification									
– System Verification									
Total Personnel									

2.9 NLS Systems Engineering and Integration

Task 2.8 is a set of NLS Systems Engineering and Integration (SE&I) charts that were presented to Dr. Luke Schutzenhofer in May of 1992. This set of charts shows how SE&I fits in the NLS organization, identifies responsibilities and major functions, provides suggestions on what tasks need to be done, and suggests how to proceed in accomplishing these tasks.

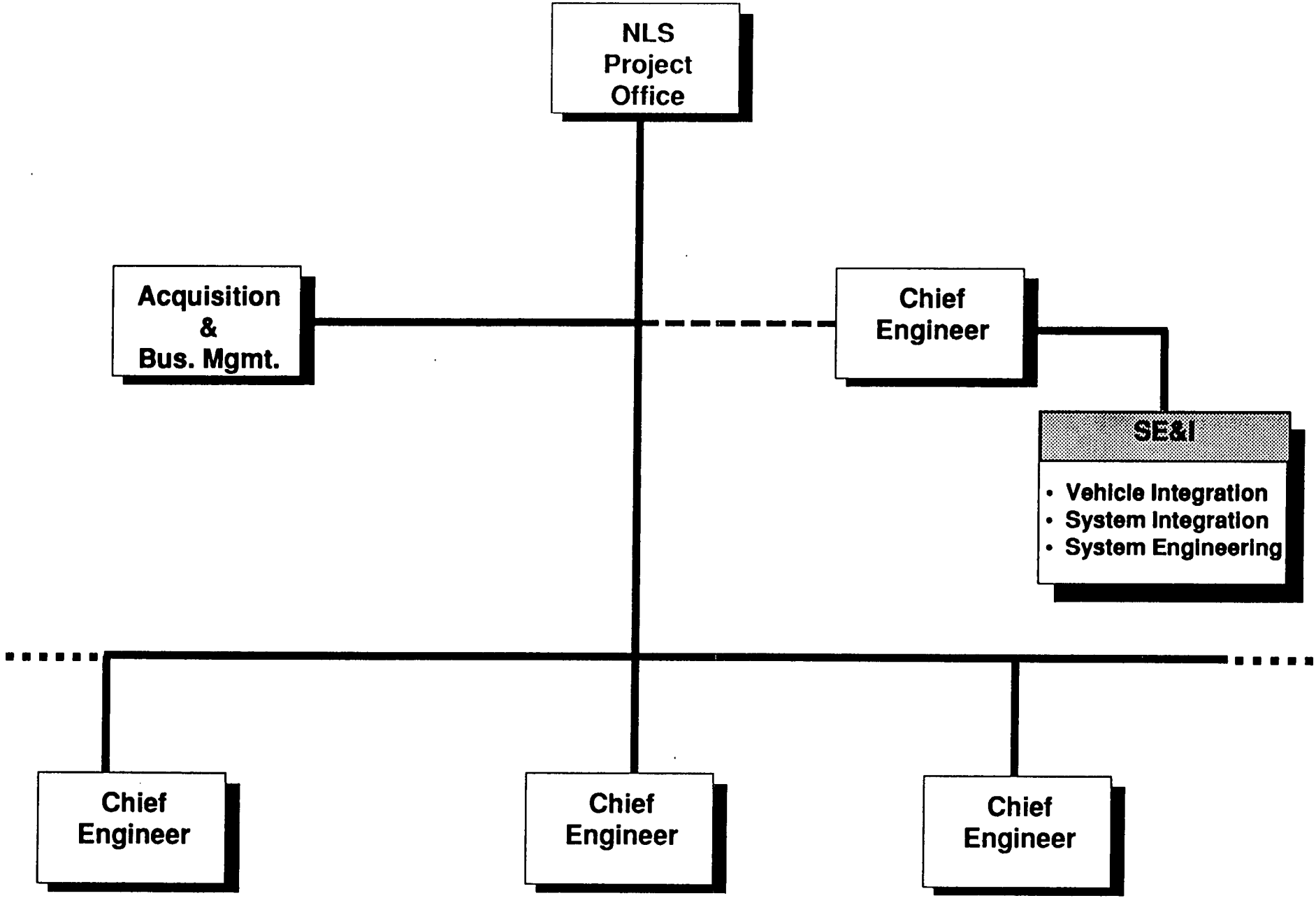
National Launch System
Systems Engineering & Integration

Organization, Responsibilities, and Planning

Systems Engineering & Integration

UNITED TECHNOLOGIES USBI

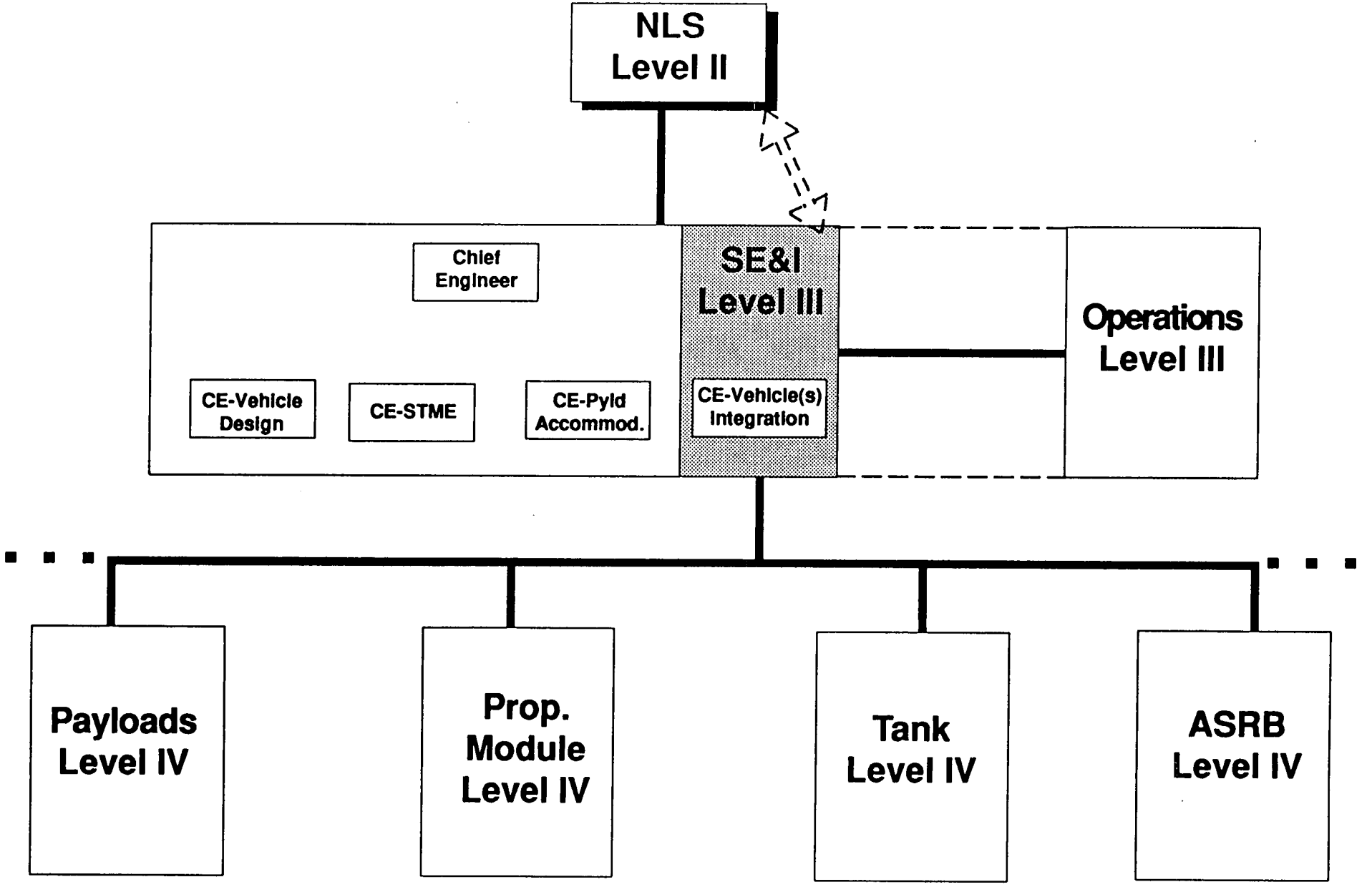
Organization/Project



Systems Engineering & Integration

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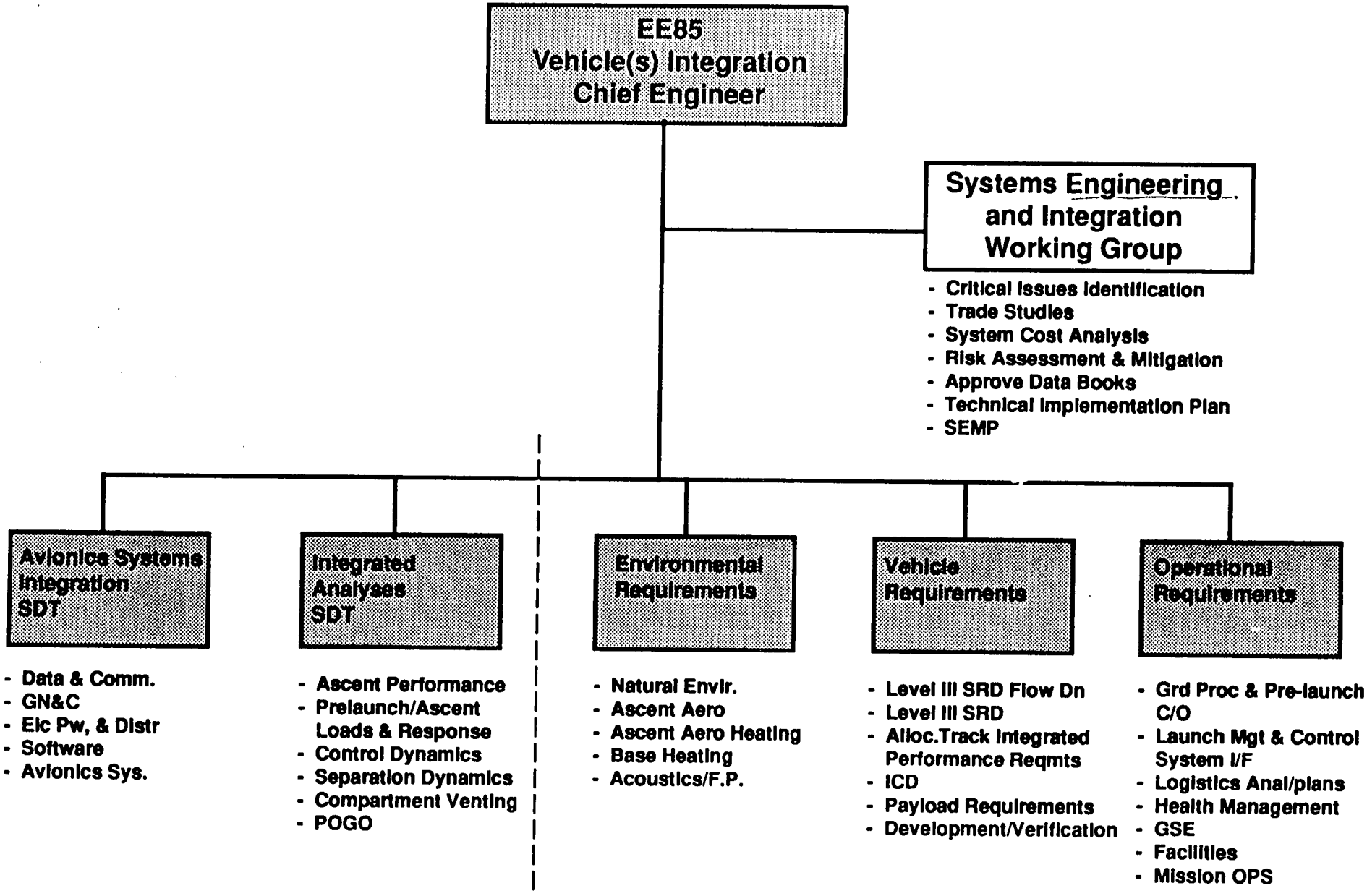
Organization/Interfaces



Systems Engineering & Integration

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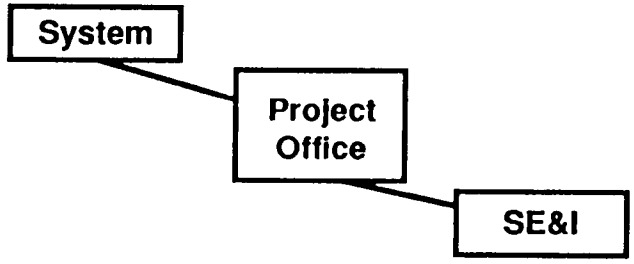
Organization/Functional Relationships



Systems Engineering & Integration

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Responsibilities/Major Functions



1. Apply both technical and management techniques to transform operational needs and mission objectives into system requirements, configurations and performance parameters.
2. Justify and validate requirements.
3. Allocate requirements and maintain a traceability database.
4. Provide functional oversight of requirements implementation via document generation and design review.
5. Optimize the system design through trade studies, analyses and assessments.
6. Establish/verify Design-to-Cost objectives.
7. Integrate the technical efforts to produce a balanced design
8. Define and ensure the compatibility of interfaces.
9. Establish and maintain a design reference baseline
10. Assess critical hardware and software anomalies, trends, etc.
11. Provide technical assessment and control of change requests
12. Ensure the qualification and validation of system products.

Planning/What Needs To Be Done

1. Review the applicability and impact of Level II requirements on Level III.
2. Consolidate and maintain project objectives, ground rules, assumptions and constraints (also, design targets).
3. Establish a method to flow-down requirements at any level to a lower level.
4. Flow-down Level II requirements and determine needed analyses, trades, and/or risk assessments.
5. Establish and maintain a requirements traceability database.
6. Develop a System Engineering Management Plan (SEMP).
7. Develop a better definition of the Design Reference Missions and investigate mission model sensitivities.
8. Develop and maintain a specification tree and a listing of applicable documents.
9. Develop and maintain appropriate WBS's and dictionaries.
10. Initiate Interface Definitions and Specifications.
11. Initiate and maintain a coordinated Design Reference Databook (mass properties, weights, c.g., cost, etc...).
12. Establish and implement a change control system that maintains the design reference baseline.

Planning/How to get the Job Done

1. Develop a Charter for EE85.
2. Develop a Strategy for Implementing the Charter (SEMP?).
3. Let the Strategy Define the Tasks, the Priorities, the Schedule, the Resources, Etc.
4. Establish an effective working relationship with Level II.
5. Utilize the MSFC Representatives at Level II (Irby, Barisa, Moore, Williams, Trucks, Cross).
6. Assign EE85 Areas of Responsibility and Oversight.
7. Establish a Technical Management Core for Coordination, Assessment and Direction of SE&I Activities.
8. Identify Involved Organizational Elements, Working Groups, PDTs, SDTs, SSTs, Etc. and Agree on Assignments and Responsibilities.
9. Establish a Monitoring and Tracking System to Measure Progress.

2.10 Level II SRD Comments

Task 2.10 is the USBI response to the MSFC requested Level II Systems Requirement Document (SRD) version 6.0 review. The response is two-fold. The first attachment is a compilation of our comments and suggestions, including a special sensitivity to cost drivers. A second attachment was also provided to MSFC. This second attachment was an SRD red-lined to highlight incidental format and grammatical comments noted during the review process.

Level II SRD, Version 6.0

General Comments

1. A requirements traceability matrix which traces all of the Level II SRD requirements back to the program (Level 1) requirements is needed. Without this traceability matrix, the validity of any of the vehicle configurations/capabilities can not be established/assessed.

2. ***There are no design-to-cost requirements in this SRD.***

3. The term "man rating" needs to be defined. Man rating is a major cost driver.

4. Appendices I, III, IV, V, VI, VII, VIII, X, and XII are not provided.

5. Requirements identified as Cost Drivers in the "Specific Comments" section below are requirements which significantly impact program cost. Identification of a requirement as a Cost Driver is not meant to imply that the requirement should be excluded from the program, it is meant only to imply that the requirement has a significant impact on program cost and that it's value to the program should be determined/assessed.

Specific Comments

Paragraph	Comments
1.0	Change "aggregation of requirements identified in ..." to "a flowdown of program requirements into system level derived requirements."
1.1	The objectives should be more specific to ensure consistent cost models. For example, the following terms are ambiguous and thus have wide interpretations: a) range of capabilities b) more operability c) significant reduction in costs d) affordable cost e) ultimately be man-rated The statement, " ... continual emphasis on meeting customer requirements" is most confusing when these are not known. *Cost Drivers:* - Provide more operability than existing vehicles - An evolutionary system which can and will accept new technologies - Ultimately be "man-rated" - Be designed with "robust systems" and subsystem margins - Provide flexibility in infrastructure to support contingencies - Employ fully integrated information system to support entire NLS life cycle - Multiple launch sites - Family of Vehicles - Missions not well defined (REFERENCE GENERAL COMMENT #1) - Capable of modular growth to support SEI planning Have the trade studies been performed? If so, these requirements need to be supported by the trades. If not, the trades need to be performed.

1.3 What drives these specific launch dates? Incremental build of the system is precluded by these dates. We need to look at an incremental build.

3.1 REFERENCE GENERAL COMMENT #1. This requirement mandates a CTV. If the CTV is not included, a big cost savings is incurred.

Has the cost trade of degree of commonality between NLS vehicles been performed (DDT&E vs Per Flight Cost)? If so, this requirement needs to be supported by that trade. If not,
the trade needs to be performed.

3.1.2.1 In compliance with paragraph 3.1.1, Mission Flexibility, the NLS #1 vehicle should not preclude missions in addition to SSF.

3.1.2.4 In addition to the listed vehicle capabilities, the CTV must also deorbit the support hardware (such as a payload strongback, if used) for SSF missions.

Cost Drivers:
- Recovery and reusability

Has a cost trade been performed? If so, this requirement needs to be supported by that trade. If not, the trade needs to be performed.

3.1.2.6 VAFB launches are not a part of the initial NLS baseline. NLS #2 (3.1.2.2) and NLS #3 (3.1.2.3) both say, "if launched from VAFB ..." Clarify when and why VAFB becomes a part of NLS, and provide traceability in the traceability matrix.

Clarify the statement, "initial vehicles will be configured commensurate with these requirements?"

3.1.2.7 ***Cost Driver:***
- Engine Out

The engine out requirement needs further clarification by adding the specific orbit to be achieved.

3.1.3.1 Suggest rewriting the paragraph as follows, "The NLS shroud and payload carrier will be capable of accommodating a STS dual class payload as well as multiple smaller STS compatible payloads. The dual class payload is defined as having a mass of 80,000 pounds, occupying a cylindrical volume 15 feet in diameter and 80 feet in length, and complying with applicable NSTS 07700 Volume 14 requirements."

3.1.4.1 The launch windows specified (+/- 1-Hour) require significant propellant or a significant performance loss. Has a cost trade been performed? If so, this requirement needs to be supported by that trade. If not, the trade needs to be performed.

3.1.5 To provide the kind of capability discussed (withstanding wind gusts, rain, hail, and direct lightning strikes) during such operations as "on/or in transit to/from the pad, in flight, etc." is very expensive. A way to reduce costs is to relax the environmental requirements to more reasonable levels. Suggestion - "otherwise protect" the vehicle.

Cost Driver
Has the cost trade been performed? If so, this requirement needs to be supported by that trade. If not, the trade needs to be performed.

3.2.2 ***Cost Driver***
- Loading and unloading cryogenic fluids

3.2.5 ***Cost Driver***
- Transport of humans

Definition of human rating is needed. (REFERENCE GENERAL COMMENT 3)

3.2.6 If the payload is inoperative, then why separate it from the core stage and allow it to decay seperately.

If the payload must be separated from the vehicle in the event of an inoperative payload, NLS must possess a means to do so (i.e., a direct interface to the payload separation mechanism). Therefore, the statement "if possible" needs to be deleted.

3.2.9 This requirement is for a secondary path. Is there a requirement for the NLS to accommodate a primary communications system path for the payload range safety system?

3.3 The statement, "The NLS will not provide operation support for payload operations" precludes CTV and payload on-orbit operations. This needs clarification.

3.3.1.1.2 ***Cost Driver***
- Building new facilities at CCAFS

Has the cost trade been performed? If so, this requirement needs to be supported by that trade. If not, the trade needs to be performed.

3.3.1.2.2 ***Cost Driver***
- Surge capability

The source of the surge requirement needs to be provided in the traceability matrix.

3.3.1.2.3 ***Cost Driver***
- Payload Assignment Changes

The requirement needs further definition to answer questions such as, "Should this requirement be restricted to DoD?" "Is it applicable to NLS #1?" This requirement, if applicable to NLS #1, implies several CTV's.

Has there been a trade study of cost versus number of days for payload replacement? If so, this requirement needs to be supported by that trade. If not, the trade needs to be performed.

3.4.2.1	This requirement needs to be defined further to specify to which "earth orbit." Any? Or a specified orbit? Suggested rewrite - payload delivery to a "designated orbit."
3.4.4	***Cost Driver*** - Dependability
3.5	The source of the cost requirements needs to be provided in the traceability matrix. These are not necessarily achievable requirements. The design requirements imposed in this SRD are not consistent with the low cost requirements of this paragraph.
3.6.2	Are the AFOSH requirements compatible with NASA requirements?
3.8	***Cost Driver*** - System Security and Program Protection This paragraph implies a DoD security classification.
3.8.4	Public Law 100-235, Computer Security Act of 1987, applies to this requirement. NMI 2410.7 governs its implementation. These should be called out in this paragraph.
3.9	***Cost Driver*** - Information System A fully integrated information system is definitely a cost driver (i.e., Appendix XI). We need to consider implementing subsets of this requirement.
3.10	The statement, "vehicle element assembly until disposal or recovery" needs to be clarified to answer questions such as, "Must the on-board system be powered up immediately and continuously after assembly?"
4.1 to 4.4	Growth requirements are premature. ***Cost Driver*** - All Growth Requirements
4.5	The source of the cost requirement needs to be provided in the traceability matrix. These are not necessarily achievable requirements. The design requirements imposed in this SRD are not consistent with the low cost requirements.
5.1.4	Add "NASA inventory" to this definition.
5.1.5	Add "TBD".
5.1.14	The statement, "simple clean pad" may be overstated. Suggestion - delete "simple clean pad" and let the pad design be derived.
5.1.18	Add "Payload" to the title.
5.1.21	Add "TBD".
5.1.26	Add "NASA inventory" to this definition.

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Appendix XI *Cost Driver*
- DSS

The characteristics shown herein are not consistent with a low-cost system:
- Adaptive Learning
- Totally Integrated
- All Encompassing
- etc

The detail in this Appendix is too much for a Level II specification.

2.2.5 This model does not exist within NASA. Is this an USAF requirement?

2.2.5.1 What is the NLS Cost Reporting Document (CRD)? Is it available?

2.11 NLS Vehicle/Main Engine ICD

Task 2.11 is a set of comments identifying formatting/grammatical inconsistencies of the NLS Vehicle/Main Engine Interface Control Document (ICD).

USBI COMMENTS TO THE NLS VEHICLE/MAIN ENGINE ICD

Page	Section	Comment
14	3.2.1,3.2.2	The text calls out Figures but pages 16-18 call out drawings. I think we should have figures and tables, but no drawings. Bob Fleenor agrees but has to work this with MSFC.
14	3.3.1	Based on the above, this drawing on page 19 should be referred to as a figure
20	3.3.1	Remove the second "the" from the 4th sentence on the page
20	3.3.1	The reference to "drawing" on this page should be changed to "figure"
21	3.3.3	The reference to "drawing" on this page should be changed to "figure". Also, this figure should be 3.3-something.
-	4.1	"design" should be "designed"
-	4.1.1	"will" should be "shall" for consistentcy. Remainder of the document should also be purged of "wills".
-	4.1.2	3rd paragraph, 1st sentence, "such as" should be "in order"
-	4.1.4.1	insert comma on second line after "Paragraph 4.1.4"

-	GENERAL	There are 2 paragraphs numbered 4.1.4. "Startup Time and Rate Requirements" should be 4.1.5. Also, Second paragraph, the second sentence should start with "The".
-	4.1.6	Remove the "will" and there is one too many "an".
	4.1.6.1	Insert comma after "4.1-3" and "is" should be "are"
-	General	Table 4.1-3 should be titled "Engine Propellant Consumption"
-	4.2.1	The second sentence should be modified to be "...variation characteristics at the standard mainstage inlet conditions of Paragraph 4.2.1.2.
-	4.2.2	Figure 4.2-2 is missing. Second paragraph, remove the word "given".
-	GENERAL	Present "Figure 4.1-2" should be "Figure 4.2-1".
-	4.3.2	Figures 4.3-2 and 4.3-3 are missing
-	4.3.3	"with out" should be "without" and remove one too many "at" in the third line.
-	4.3.8	Third sentence, the second "hydrogen" should be "oxygen". Last sentence, insert "be" after "shall".
-	4.4.2	"total of 1000" times?

2.12 Comparison of Level III NLS SRD (v6.0) with MSFC Reqt-1978

Task 2.12 is a comparison of the NLS Level III Systems Requirement Document (SRD), version 6.0, with MSFC-Requirement-1978 dated January 1, 1992. This set of comments identifies many inconsistencies between the Level III SRD and the Level II SRD.

USBI Co.
COMPARISON OF
NATIONAL LAUNCH SYSTEM PROGRAM
SYSTEM REQUIREMENTS DOCUMENT (VERSION 6.0)
31 JANUARY 1992
SPO-NLS-R-SRD-v6.0
with
MSFC-RQMT-1978
1/31/92

MSFC-RQMT-1978 PAGE	PARAGRAPH	CHANGE
1	1.2	Change: "....NLS Launch Vehicles to support the 1.5 Stage and the Heavy Lift Launch Vehicle (HLLV) payloads." to read: "...NLS Launch Vehicles to support NLS Vehicles #1 and #2 payloads." Justification: Level II SRD paragraphs 3.1.2.1 and 3.1.2.2.
1	1.2	Change: "....document consist of the common Core Stage (CS), Space Transportation Main Engines (STME), Advanced Solid Rocket Boosters (ASRBs),Cargo Transfer Vehicle (CTV), Payload Carrier (PC), and Forward Propulsion Module (FPM). Other launch vehicle elements provided by the Air Force (AF) Space Systems Division (SSD) and referenced herein are the Titan IV-Derived Payload Carrier (TIV-PC) and the Upper Stage (US)." to read: ".....document consist of NLS Vehicle #1 (NLS 1), NLS Vehicle #2 (NLS 2), Cargo Transfer Vehicle (CTV), NLS Upper Stage (NLSUS), Space Transportation Main Engines (STMEs) and Solid Rocket Boosters (SRBs)." Justification: Level II SRD paragraphs 3.1.2.1, 3.1.2.2, 3.1.2.3, 3.1.2.4 and 3.1.2.5.
1,2	1.3	Change: "...the presently defined missions. One configuration is an HLLV to be launched from KSC Launch Complex 39 with performance requirements for at least 80 Klbs payload (orbit inclined 28.5 deg) to Space Station Freedom (SSF). The second configuration is a 1.5 Stage liquid propellant vehicle to be launched from either Cape Canaveral AF Station(CCAFS) Launch Complexes 34 and 37, or Kennedy Space Center (KSC) Launch Complex 39, with performance requirements for a least 50Klbs payload to a 28.5 deg inclined low earth orbit (LEO). The 1.5 Stage vehicle may also " to read: "...the presently defined missions. The NLS 1 configuration is to be launched from KSC Launch Complex 39 with performance requirements for a least

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		80 Klbs payload plus the weight of the CTV (220 nmi. circular orbit inclined 28.5 deg) to Space Station Freedom. The NLS 2 configuration is a liquid propellant vehicle to be launched from either Cape Canaveral AF Station (CCAFS) Launch Complexes 34 and 37, or Kennedy Space Center (KSC) Launch Complex 39, with performance requirements for a least 50 Klbs payload to an 80 x 150 nmi., 28.5 deg orbit. NLS 2 may also be launched from Vandenberg Air Force Base with performance requirements for at least 32 Klbs payload to an 80 x 150 nmi., 90.0 deg orbit.' Justification: Level II SRD paragraphs 3.1.2.1 and 3.1.2.2.
2	1.3.1	Delete 1.5 Stage Launch Vehicle Configuration and insert NLS 1 description. Change to read: "The elements of the NLS 1 vehicle shown in Figure 1-1 consist of a LOX/LH_2 core, SRB's and Cargo Transfer Vehicle (CTV). The NLS 1 core will have a high degree of commonality with the core of the NLS 2."
2	1.3.1.1	Delete. Justification: Level II SRD Paragraph 3.1.2.
2	1.3.1.2	Delete. Justification: Level II SRD Paragraph 3.1.2.
3		Replace Figure 1-1 with NLS 1 configuration.
4	1.3.1.3	Move to paragraph 1.3.2.1 and change to read: "The LOX/LH_2 propelled NLSUS when used with (or as a part of) the NLS 2 will provide a rated lift capability of a least 15,000 lb. to a geosynchronous earth orbit (GEO) assuming no RAAN requirement. The NLSUS will be capable of withstanding the flight environment of the NLS 1."
4	1.3.2	Delete HLLV Configuration and insert NLS 2 description.
4	1.3.2.1	Delete Core Stage and insert NLSUS paragraph above.
4	1.3.2.2	Change ASRB to SRB.
4	1.3.2.3	Delete Payload Carrier. Justification: Level II SRD Paragraph 3.2 does not include this item.
6		Delete Figure 1-3.

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7	1.3.2.5	Delete Forward Propulsion Module (FPM). Level II SRD does not identify a FPM.
13,14, 15,16	3.1.1	Replace 1.5 Stage Launch Vehicle and HLLV with NLS 1 and NLS 2 performance data from Level II SRD.
15	3.1.1.4.1	Change to NLS 1 "The NLS 1 will be capable of accommodating a STS Dual Class Payload. The shroud for the NLS 1 shall be capable of accommodating a Shuttle Transportation System (STS)-compatible cargo carrier."
15	3.1.1.4.2	Change to NLS 2 "The NLS 2 shall be capable of accommodating payloads defined by a cylinder 15 feet in diameter and lengths up to 60 feet."
16	3.1.2	Change nomenclature to replace 1.5 Stage and HLLV with NLS 1 and NLS 2.
18,19,20,21 22,23,24	3.3	Change Operations Requirements to reflect operations in paragraph 3.3 of the Level II SRD.
25	3.4.1	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
25,26	3.4.3	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
26,27	3.4.4	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
27	3.4.4.1	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
27	3.4.4.3	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
29	3.4.6	Change 1.5 Stage and HLLV to read NLS 1 and NLS 2.
29	3.4.6.1	Change second sentence to read: 'NLS 1, NLS 2, CTV, NLSUS and SRB pyrotechnic components....."
30,31	3.4.9	Change mass properties to reflect NLS 1 and NLS 2 mass properties.
32	3.4.10	Change to read: "The NLS system design shall include a Health Management System (HMS). The HMS will provide ground and vehicle subsystems data and overall system status. The HMS shall include monitoring, test, failure management and redundancy management capabilities from vehicle element assembly until disposal or recovery. HMS systems should incorporate the following features: o Compact, lightweight

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		o Built-in-test (BIT) o Automated o Reliable o Potential for integration with a (computer-driven) controller o Direct (non-inferential) measurements o Indirect measurements o Intelligent, i.e., go -- no-go instructions for maintenance personnel o On-condition maintenance (no routine scheduled maintenance)
32,33	3.4.10.1	Change to read: "NLS 1 and NLS 2 shall incorporate distributed fault tolerance and vehicle health management hardware/software systems for launch vehicle automated checkout and operation. The designs shall incorporate fault tolerance and vehicle health management hardware/software systems for: A. Launch vehicle automated checkout and operation B. CTV/NLSUS/SRB/payload checkout and operation The health management system shall be capable of detecting and isolating abnormal performance and impending failures, to the Line Replaceable Unit (LRU) level and identifying corrective actions, including reconfiguration or shutdown."
33	3.4.10.2	Fault-tolerant avionics hardware and software shall be incorporated into the NLS 1 and NLS 2 design to provide real-time fault management and reliability equivalent to that of redundant reusable systems, but compatible with the low-cost expendable system objectives of the NLS.
36	3.4.11.4	Change second paragraph to read: "NLS 1 and NLS 2 avionics shall be designed to provide for throttling, staging and abort capabilities."
38	3.4.11.8	Change second sentence to read: "There shall be a DFI system on four flights of both the NLS 1 and NLS 2 configurations (total of eight flights).
38	3.4.12	Change 1.5 Stage and HLLV to NLS 1 and NLS 2.
39,40,41 42,43,44 45,46,47 48,49,50 51	3.5	Change this section to reflect NLS 1 and NLS 2.

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52,53,54 55	3.6	Rewrite this section to satisfy the Level II SRD for NLS 1 and NLS 2.
56	3.7	Change first sentence to read: "The CTV is required for the NLS 1 Space Station support missions and the delivery of NLS 1 payloads to a circularized LEO."
66	3.11	Change first sentence to read: "The STMEs shall provide the required propulsion to achieve the NLS 2 performance and, in conjunction with the SRBs, the NLS 1 performance."
66	3.11.1	Change thrust level to 650 Klbs.
68	3.12.2	Change from 1.5 Stage to NLS 2
68	3.12.2.2	Delete.
68	3.12.2.3	Change title to NLS 2/Payload and sentence to read: "The NLS 2 shall interface with the Payload, ..."
68	3.12.2.4	Change 1.5 Stage to NLS 2.
68	3.12.3	Change HLLV to NLS 1.
68	3.12.3.1	Change ASRB to SRB.
69	3.12.3.10	Change HLLV to NLS 1.
71	3.14	Change 1.5 Stage and HLLV to NLS 1 and NLS 2.
75	3.16.1	Change 1.5 Stage and HLLV to NLS 1 and NLS 2.
91	4.4.4	Change 1.5 Stage and HLLV to NLS 1 and NLS 2.